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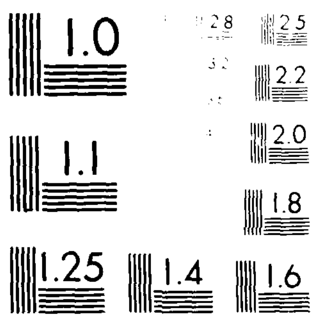
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Review and Recommendations for the Interagency Ship Structure Committee's Fiscal 1983 Research Program and Five-Year Research Program Plan

Ship Research Committee
Maritime Transportation Research Board
Commission on Sociotechnical Systems

MARITIME TRANSPORTATION RESEARCH BOARD

Commission on Sociotechnical Systems

National Academy of Sciences -- National Research Council

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REVIEW AND RECOMMENDATIONS

for the

INTERAGENCY

SHIP STRUCTURE COMMITTEE'S

FISCAL 1983 RESEARCH PROGRAM

and

FIVE-YEAR RESEARCH PROGRAM PLAN

A Report Prepared

by the

SHIP RESEARCH COMMITTEE

of the

Maritime Transportation Research Board

Commission on Sociotechnical Systems

National Research Council

National Academy Press
Washington, D.C.
March 31, 1982

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the Councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the Committee responsible for the report for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

The National Research Council was established by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and of advising the federal government. The Council operates in accordance with general policies determined by the Academy under the authority of its congressional charter of 1863, which establishes the Academy as a private, nonprofit, self-governing membership corporation. The Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in the conduct of their services to the government, the public, and the scientific and engineering communities. It is administered jointly by both Academies and the Institute of Medicine. The National Academy of Engineering and the Institute of Medicine were established in 1964 and 1970, respectively, under the charter of the National Academy of Sciences.

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This report was prepared for the interagency Ship Structure Committee, consisting of representatives from the Military Sealift Command, the U.S. Coast Guard, the Naval Sea Systems Command, the Maritime Administration, the American Bureau of Shipping, and the U.S. Geological Survey, and is submitted to the Commandant, U.S. Coast Guard, under provisions of Contract DOT-CG-23-81-C-20044 between the National Academy of Sciences and the Commandant, U.S. Coast Guard, acting for the Ship Structure Committee.

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ABSTRACT

The Ship Research Committee (SRC) of the National Research Council provides technical services covering program recommendations, proposal evaluations, and project advice to the interagency Ship Structure Committee (SSC), composed of representatives from the U.S. Coast Guard, the Naval Sea Systems Command, the Military Sealift Command, the Maritime Administration, the American Bureau of Shipping, and the U.S. Geological Survey. This arrangement requires continuing interaction among the SRC, the SSC, the contracting agency, and the project investigators to assure an effective program to improve marine structures through an extension of knowledge of materials, fabrication methods, static and dynamic loading and response, and methods of analysis and design. This report contains the Ship Research Committee's recommended research program for five years, FY 1982-1986, with 13 specific prospectuses for FY 1983. Also included is a brief review of 21 active and 9 recently completed projects.

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SHIP STRUCTURE COMMITTEE

The SHIP STRUCTURE COMMITTEE is constituted to prosecute a research program to improve the hull structures of ships and other marine structures by an extension of knowledge pertaining to design, materials and methods of construction.

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The SHIP STRUCTURE SUBCOMMITTEE acts for the Ship Structure Committee on technical matters by providing technical coordination for the determination of goals and objectives of the program, and by evaluating and interpreting the results in terms of structural design, construction and operation.

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INTRODUCTION

Organizational and Administrative Matters

Establishment of Committees

Since 1946, the National Research Council's Ship Research Committee (SRC) and its predecessors have been rendering technical services to the interagency Ship Structure Committee (SSC) in developing a continuing research program, sponsored by the SSC and funded collectively by its member agencies, to determine how marine structures can be improved for greater safety and better performance without adverse economic effect.

The SSC was established in 1946 upon recommendation of a Board of Investigation, convened by order of the Secretary of the Navy, to inquire into the design and methods of construction of welded steel merchant vessels. As that investigation was brought to a close, several unfinished studies and a list of worthy items for future investigation remained. The Board of Investigation recommended that a continuing organization be established to formulate and coordinate research in matters pertaining to ship structure. Figure 1 shows the relationship of the various organizational entities involved in the work of the SSC.

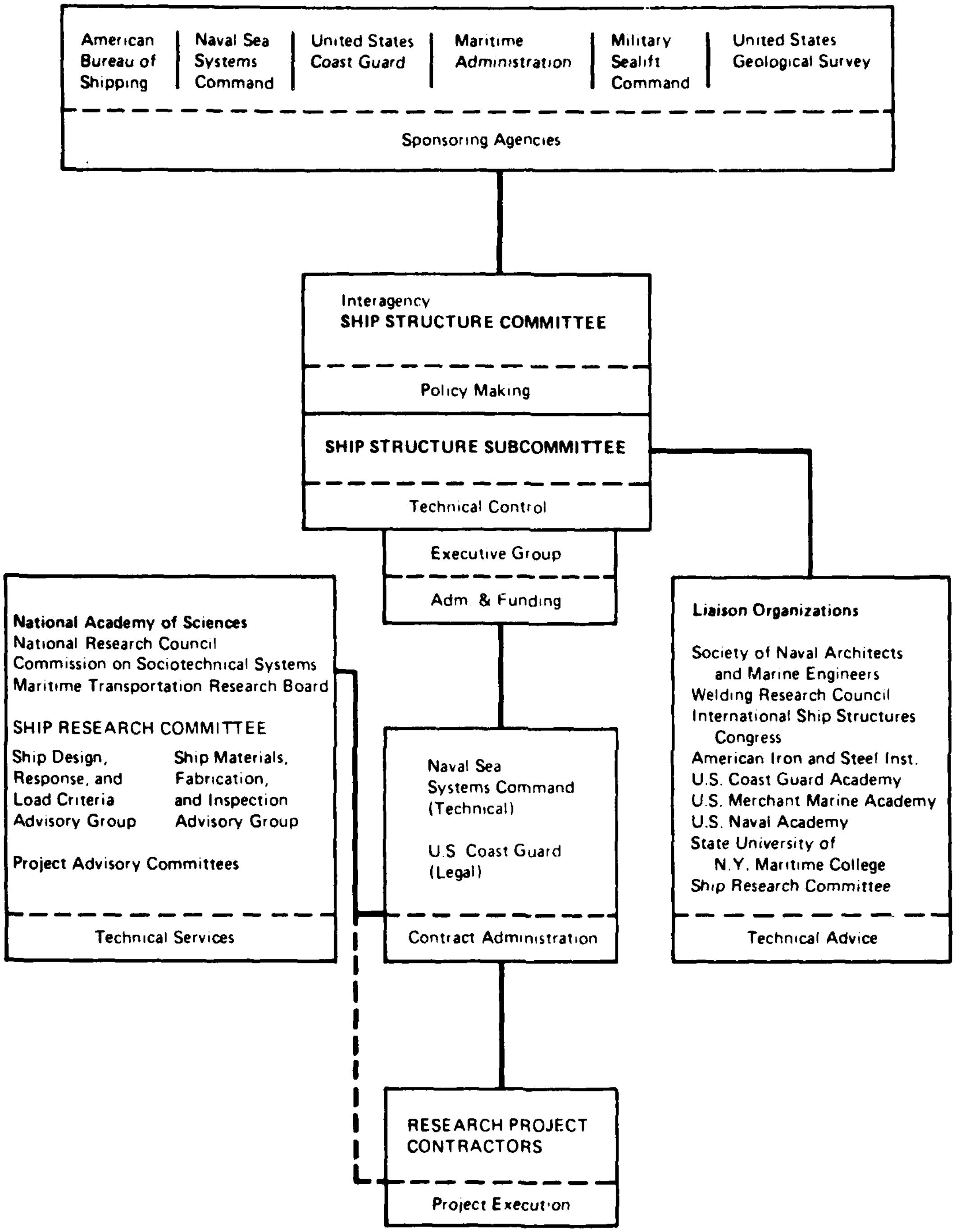


FIGURE 1. SHIP STRUCTURE COMMITTEE ORGANIZATION CHART

Committee Composition and Responsibilities

The SSC is composed of senior officials, one each, from the U.S. Coast Guard, the Naval Sea Systems Command, the Military Sealift Command, the Maritime Administration, the American Bureau of Shipping, and the U.S. Geological Survey.

The SSC formulates policy, approves program plans, and provides financial support through its member agencies for the research program.

A maximum of four representatives from different divisions within each agency meet periodically as a Ship Structure Subcommittee (SSSC) to assure achievement of program goals and to evaluate the results of research projects in terms of structural design, construction, and operation.

Members of the SRC and its advisory groups are selected for their competence and experience in relevant areas from academic, governmental, and industrial sources. The members serve as individuals, contributing personal knowledge and judgement, and not as representatives of organizations where they are employed or with which they may be associated. The SRC's responsibilities to the SSC are to assist in setting technical objectives; define research projects; recommend research priorities; evaluate proposals; review the active projects, including progress and final reports; and prepare summaries of related research work.

Research Program Development

This year, as had been done prior to 1980, a joint meeting was held in early September 1981 among members of the SRC, the SSSC, and the Hull Structure Committee (HSC) of The Society of Naval

Architects and Marine Engineers (SNAME). This meeting had the objective to foster an awareness of the state of the art of projects related to the operational, performance and materials testing, and instrumentation as related to marine structures and to encourage the presentation of candidate projects for future consideration. There were 13 prepared discussions and several candidate projects presented.

Following this joint meeting, the SRC held its annual fall meeting to prepare a presentation to the SSC. A number of matters were reviewed which included SRC member suggestions for research projects, research suggestions from SSC project reports recently published and yet to be published, the SSC five-year research program plan, prospectuses not currently funded, and joint committee and agency suggestions. Last year's SRC list of 59 potential projects was also reviewed and all items thereon were either assigned a role in the SRC program in the form of prospectuses or as short statements entered in the five-year plan, or were set aside from further consideration with the concurrence of SSC as indicated at the SSC 1980 fall meeting.

In mid-October 1981 at the fall meeting of the SSC, the SRC presented a proposed program of 16 research projects (all described in some depth) and obtained specific reaction from the member agencies of the SSC on each.

Project Development

With the SSC opinions in hand, all the suggestions for research projects were carefully studied for applicability to the SSC research program in terms of need, immediacy, program continuity, and likelihood of successful and meaningful completion. A prospectus was

drafted by the appropriate SRC advisory group for each of the research projects or combination thereof that was considered worthy of SSC support. These were reviewed and ranked by the SRC and are included in this annual report to the SSC.

The SSC determines which projects will be supported. A Request for Proposal (RFP) is then prepared and issued through the cooperative effort of the Naval Sea Systems Command, which provides technical contract administrative support services, and the U.S. Coast Guard, which handles the actual business of contracting. The RFPs go to research laboratories, universities, shipyards, and other organizations and are advertised in the Commerce Business Daily.

Proposal Evaluation Procedure

An organization interested in doing work submits a proposal and an estimated cost. The USCG Contracting Office removes the cost data and transmits the technical data in the proposal to the SRC for technical evaluation and review.

The SRC Executive Secretary verifies that no SRC or advisory group member or affiliated company is represented in the proposals. This important step avoids conflict of interest. The SRC chairman selects an *ad hoc* proposal evaluation committee that generally consists of the Chairmen of the SRC and the pertinent advisory group and two or three other members from either the advisory group or the SRC.

The proposals are evaluated for the analysis of the problem, the proposed solution, the assessment of the scope of the effort, and the adequacy of the organization and personnel.

After the evaluation committee judges the technical merit of the proposals, ranks them, and comments on any shortcomings, the USCG Contracting Officer forwards the technical evaluation and cost data to the SSC. The SSC considers the proposals together with the technical evaluation and costs and sends its recommendations to the Contracting Officer, who, following routine procurement practices, then awards a contract.

Dissemination of SSC Research Information

The contractors prepare reports upon completion of a coherent series of tests or discrete unit of work, upon a major change of course in a project, upon a significant discovery, or upon termination of a project. Normally, such reports are published by the SSC to fulfill its mission of disseminating the results of research pertaining to marine structures. In addition, the investigators are encouraged to prepare papers for presentation before professional society meetings or for submission to technical journals.

To foster the use of the published information, the reports are distributed to individuals and agencies associated with and interested in the work of the SSC. Their availability is also noted by the National Technical Information Service (NTIS), and in various marine and naval architecture journals. Further, over a hundred leaders and officers of the marine structure community receive personal copies directly from the Chairman, SSC, to further embed this new information in the working design industry.

Annual Report Summary

Status and progress of SRC-SSC research activities and SRC recommendations to the SSC for continued and new research to be funded during the ensuing fiscal year are submitted annually.

This, the latest in the series of annual reports, covers research activities during FY 1982, sets forth recommendations for the SSC's FY-1983 research program, and outlines a five-year research planning program.

Five-Year Research Program Plan Development

A continuing program of research in marine structures must be guided by a perception of the directions in which marine activity is moving. The FY-1983 program and the associated five-year plan are aimed at producing programs that will support emerging needs of marine development as they can best be perceived at this time. Last year it was felt that the most significant areas of concern for research were fracture, vibration, ice strengthening, fatigue and corrosion. Little has occurred to alter this, but in some areas new perceptions of emphasis and relationships have developed, e.g., design-inspection-redundancy and material-design-fabrication.

Design-Inspection-Redundancy

The emergency technologies of ultimate strength and failure mode of analysis have indicated a relationship among design-inspection-redundancy not heretofore fully appreciated. The degree of fail-safe redundancy (multiple load paths) and element ductility which have been incorporated into the design of a marine

structure has important implications in terms of its tolerance for flaws and/or overloads, and influences the strategies to be adopted for inspection and repair throughout its lifetime. Marine structures are subject to unexpected or premature failure by buckling, fatigue, or fracture.

Buckling failures of elements are influenced by the imperfections present, both those which are permitted during construction and those which are introduced in service due to slamming, minor collisions, etc. For tubular bracing elements and for shell and stiffener elements, peak capacity is maintained for only a limited range of ductility, after which the element degrades and unloads. The overall strength and ductility of the structural system depends not only on these characteristics of the elements, but also on the ability of the system to accommodate the unloading of individual elements as they fail. This ability depends on the configuration of the system, which includes the degree of redundancy at each level or frame, as well as the degree of complexity.

Fatigue failure is also progressive, in terms of both crack growth in an individual element and load shedding from failed elements to intact elements in the system. Total fatigue life depends on the initial flaws permitted during construction. At some later time in the life of the structure, the remaining life can be related to the current state of fatigue damage. Again, the damage tolerance of the system, and the ability to detect damage depend on the configuration of the system.

Fracture control involves not only the selection of notch-tough materials, but also interrelated strategies for design, welding, inspection, and lifetime maintenance, appropriate to the structure's conditions of service and the consequences of its failure. Damage due to fatigue and repeated local buckling can lead to terminal failure by fracture. As with the other failure modes, the tolerance of the structure for flaws and isolated fractures is highly dependent on its degree of redundancy.

Step-by-step tasks cannot be outlined at this time and considerable insight is necessary in order to achieve the desired synthesis of these relationships. Thus, to examine the to examine the relationships in more detail, the FY 1983 program calls for a workshop which will focus on the emerging technologies of ultimate strength and failure mode analysis, as applicable to design-inspection-redundancy for marine structures. Following this, a three-year program of research is envisioned which will:

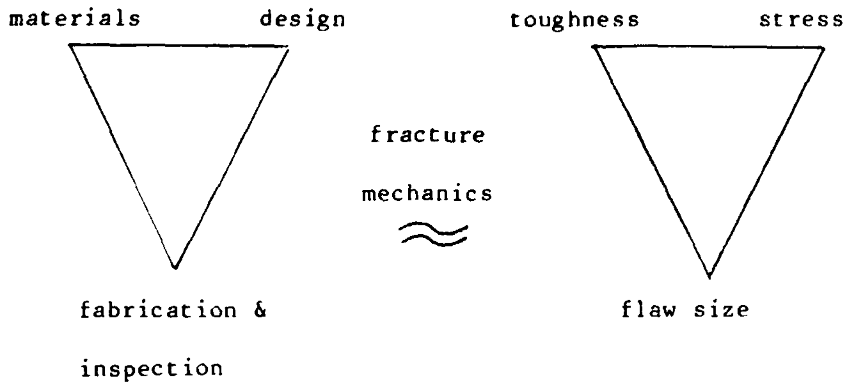
1. Study the successive transfer of load and progressive failure in redundant parallel load path structures, considering such modes as buckling, fatigue, and fracture.
2. Synthesize the results in terms of the influence of various initial imperfections and subsequent damage on reliability, considering the role of structural redundancy.

3. Review the impact of these findings on the choice of strategies and criteria for inspection and monitoring, specialized to various types of marine structures.

Material-Design-Fabrication

Designers and engineers have known for many years that there are three primary factors that control the susceptibility of a structure to brittle fracture; namely: material toughness, stress level, and flaw size. All other factors, such as loading rate, temperature, environment, etc., can be considered as merely affecting the three primary factors. This concept has been applied in a more or less qualitative sense by using such things as Charpy V-notch impact tests to assure adequate notch toughness, by minimizing flaw size through adherence to adequate welding workmanship quality levels, and by proper selection of design details to minimize stress concentrations.

Over the past decade, considerable progress has been made in technologies used to assure the structural integrity of marine structures. These include fracture mechanics, new methods of stress analysis and improved nondestructive inspection techniques. The concepts of fracture-control plans and fitness-for-service analyses have incorporated an evaluation of materials, design, and fabrication with inspection. As shown in the figure below, fracture mechanics may provide the quantitative link for designers and engineers to tie together the primary factors controlling brittle fracture, thus:



Fracture mechanics define the level of admissible defects at a given operating stress in a structure or, conversely, define the allowable stress for a given detectable defect size. The benefit of this approach is that it combines (1) the efforts of the material producer, since toughness and other mechanical properties are a function of material quality, (2) the efforts of the designer through proper analysis of stresses and (3) the efforts of the fabricator and the inspector through the detectable defect size.

This is all expressed in its simplest mathematical form by the equation: $K \sim \sigma\sqrt{a}$

"K" is used to denote material toughness. It can be defined as resistance to crack propagation in the presence of a notch and can be measured by a variety of methods. It is a function of material quality, which relates to the producer through composition and processing, and it is a function of service environment, e.g., temperature, loading rate, thickness, etc., that can be related to fatigue and corrosion parameters.

"σ" is the stress present in a particular structural application. Stresses in complex structures are difficult to analyze, but significant progress is being made in this area through the use of the finite-element method, and, from a practical sense, measuring the effect of details or stress concentrations on fatigue properties.

"a" is the flaw size. Although control is exercised during fabrication, and although new and improved inspection techniques, automated welding, and improved filler metals are utilized, flaws or discontinuities are still assumed to be present in all welded structures.

Applied fracture mechanics is based on the concept that all fractures occur progressively from some pre-existing crack or crack-like defect. Since fracturing of the complete structure is determined solely by the behavior of the crack tip, it is possible to model the complete structure by the use of reasonably small specimens containing cracks. The difficulty in doing this is one of being certain that the crack tip in the specimen does, indeed, experience conditions that are identical to that of a precracked structure. Sometimes this is not difficult; for example, a specimen can be developed that simulates a plate-like structure subjected to an alternating stress. If the structure is a weld detail containing a crack, then developing an adequate specimen to model the detail is more difficult. Nevertheless, the combination of sophisticated stress analysis and currently used fracture-mechanics analysis methods is able to treat problems of even this complexity.

Applied fracture mechanics is an active area of research, and the kinds of problems that can be treated are constantly expanding. In spite of the fact that these developments might not seem to be applicable to ship structures, their usefulness becomes apparent on closer examination. For example, one area that has progressed from the research to the application stage is the development of fracture-control plans for arresting fast running cracks. This was initially developed for designing against thermal shock where crack initiation cannot be avoided because of the large stresses generated in the small volume of metal where the thermal shock occurs. As the crack extends into a less heavily stressed region, it can be made to arrest, however. The problems that were solved for this fracture-control program are similar to those encountered in the design of arrestor plates in ships. Hence, the concepts that were used in the thermal shock problem might be used to assist in deciding how large arrestor plates must be; how far apart they should be placed; and what their toughness need be.

In recognizing the importance of the interrelationship among these factors, the FY 1983 program contains projects in the areas of material behavior after fatigue loading, the effect of specific weld defects on material toughness, and on the impact of automatic fabrication and inspection on the integrity of ship structure.

Five-Year Research Program Plan

The five-year research planning program depicted in Table I builds on current activities and places them in perspective with

contemplated work in various project areas during the next four years. The program is classified under the following seven goal areas of the SSC:

Advanced Concepts and Long-Range Planning
Loads Criteria
Response Criteria
Materials Criteria
Fabrication Techniques
Determination of Failure Criteria (Reliability)
Design Methods

Work in each of these areas includes adequate verification procedures to ensure that sound recommendations are made. The thrust is to expand the existing base of knowledge in each area that will result in design methods, fabrication procedures, and materials for safer and more efficient marine structures.

It is intended that the program be dynamic and flexible so that it can be modified and redirected to be responsive to changing circumstances.

TABLE 1--SHIP RESEARCH COMMITTEE RECOMMENDATIONS FOR AN SSC FIVE-YEAR RESEARCH PROGRAM

Project Area	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986
GOAL AREA: I - ADVANCED CONCEPTS AND LONG-RANGE PLANNING					
Overall research planning studies	*Conduct SRC-SSSC-HSC joint meeting to discuss current efforts and planned research work in robotics.*	*Conduct SRC-SSSC-HSC joint meeting to discuss current efforts and planned research work in vibration.*	*Conduct SRC-SSSC-HSC joint meeting to discuss current efforts and planned research work on ice loads.*	*Conduct SRC-SSSC-HSC joint meeting to discuss current efforts and planned research work in computer applications.*	*Conduct SRC-SSC-HSC joint meeting to discuss current efforts and planned research work on fatigue.*
	Further develop Long-Range Research Plan. (SR-1296)	*Implement research planning.*			
Conduct technical Symposia	**Conduct Extreme Loads Response Symposium.**	*Consider topics for FY 1985 Symposium.*	*Begin preparations for FY 1985 Symposium.*	*Conduct Symposium.*	*Consider topics for FY 1988 Symposium.*
		Begin preparations for a Design--Inspection--Redundancy Symposium/ Workshop for FY 1984. (83-1)	*Conduct Symposium. (83-1)*		

Key:

Bold-face type refers to completed, active, and pending projects, and committee efforts. (SR-0000) designation refers to projects described in the yellow pages of this report.

Italic type refers to proposed projects and research efforts. (83-00) refers to project recommendations described in the green pages of this report.

TABLE I (Continued)

Project Area	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986
	GOAL AREA: I - ADVANCED CONCEPTS AND LONG-RANGE PLANNING (Continued)				
Materials & their applications					
Concrete	Complete a survey of construction & operating experience of marine concrete structures. Develop the basis for a research program to provide guidance & recommendations to designers & builders of floating structures. (SR-1270)	*Evaluate recommendations for follow-on research.*	*Begin specific projects.*	*Continue specific research as indicated by previous work.*	
Arctic materials	Emphasize need for USGS's program to include survey of steel material property data for applications in Arctic conditions.	*Review USGS program to determine if a feasibility study should be started.*	*Undertake new material research relevant to Arctic resource development.*	*Continue research.*	*Review results in terms of actual application.*
Cu-Ni clad steels	Follow SNAME HS-9 panel's project for the economic analysis and technical awareness of Cu-Ni clad steels.	*Review HS-9 panel's results.*	*Consider program to augment the HS-9 work in this area, if warranted.*	*Initiate and carry out program.*	*Continue effort.*
High-performance marine structures		*Examine material data for advanced marine craft and identify requirements and necessary test program. (83-9)*	*Review HS-8 results and develop prospectus to conduct experimental program to obtain required material data for high-performance craft.*	*Continue high-performance craft material data gathering.*	*Complete experimental program and results.*

TABLE I (Continued)

Project Area	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986
GOAL AREA: I - ADVANCED CONCEPTS AND LONG-RANGE PLANNING (Continued)					
Fabrication inspection		*Assess the impact of automated fabrication technologies and automated NDI on the integrity of marine structures. (83-10)*	*Evaluate recommendations for follow-on developments.*		
GOAL AREA: II - LOADS CRITERIA					
Static/quasi-static	Develop program to obtain still-water bending moment data for typical ships. (SR-1282)	*Review SR-1282 recommendations.*			
		Develop prospectus to conduct data collection program.	*Conduct data collection program.*	*Continue data collection program. Review first-year results.*	*Complete data collection program. Evaluate results.*
			Write prospectus for program to assess interrelationships and nonlinearity effects of various load conditions in different parts of ship structure.	*Assess interrelationships and nonlinearity effects of various load conditions in different parts of ship structure.*	*Prepare design load profiles & recommend modifications to design criteria.*
Dynamic	Compile, review & correlate model & full-scale liquid slosh data. Devise & conduct model tests with various fill depths, specific densities, geometries and excitations. (SR-1284)	Develop general-purpose curves & tables of dynamic loading data for use in design of liquid cargo tanks. (SR-1284)	*Review SR-1284 data and determine if further research efforts are required.*		

TABLE I (Continued)

GOAL AREA: II - LOADS CRITERIA (Continued)

Project Area	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986
Dynamic (Continued)			*Develop plan to review & categorize types of shifting cargo loads, & establish priority of dynamic load problems.*	*Conduct analyses and tests to establish dynamic loads & corresponding structural response to shifting cargo under typical operational conditions.*	*Develop curves & tables for ready use in design for dynamic loads due to shifting cargo.*
	After a review of Navy design data sheets on wheel loads is done by the US Navy, subsequent reviews and analyses may proceed.				
Wave-induced	Develop a model and background material to statistically estimate frequencies of joint occurence of winds and waves. (SR-1287)				
	Develop detailed plan for full-scale slam instrumentation and wavemeter data collection on oceangoing ship, with due consideration for follow-on model tests. (SR-1295)	Conduct full-scale slamming, bow-flare, and green-water impact trials to collect data using instrumentation and plan developed under SR-1295.	Analyze impact pressures and velocities and compare them with theoretical results. (SR-1295)		
			Conduct model tests duplicating full-scale tests. Compare results with prototype and theory.		

TABLE 1 (Continued)

Project Area	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986
GOAL AREA: II - LOADS CRITERIA (Continued)					
Wave-induced (Continued)			Develop a method to statistically estimate the combined [illegible] bending and torsional loads [illegible] structural failure analysis.		
	Survey and analyze experience of vessels encountering extreme waves. (SR-1281)	Review SR-1281 results and determine if additional studies or data gathering is required.	Consider using gages on several ships being routed through oceans where they might encounter extreme waves.	Periodically check gage records to determine if design changes might be needed.	
	Formulate a hydrodynamic model for predicting ship motions and wave loads above and below the still-water line. (SR-1277)	Develop a motions and distributed loads computer program accounting for hull shape above and below the still-water line. (SR-1277)	Complete SR-1277 and review results.		
			Develop analytical procedures for solving the coupled fluid-structure interaction problem.	Compare analytical results with model or full-scale data.	Modify procedure where required.
Collisions & groundings	Develop specifications for calculation aids for the assessment of damage, stability, and survivability of grounded vessels. (SR-1304)				

TABLE I (Continued)

Project Area	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986
GOAL AREA: II - LOADS CRITERIA (Continued)					
Collisions & groundings (Continued)			*Develop grounding loads & analysis logic for a computer program.*	*Develop grounding loads & analysis computer program.*	*Develop logic to incorporate dynamic loading. Expand grounding loads & analysis computer program with dynamic loading capacity.*
			Establish feasibility for model simulation of groundings according to various scenarios & associated model experiments.	*Investigate interim design proposals to limit grounding damage.*	
			Investigate the common technologies and engineering analysis applicable to both ship collision and grounding problems.	*Develop analytical procedures for low-energy collision & grounding including studies by ship type.*	*Develop generalized design guidelines for low-energy collision & energy absorption criteria & parametric studies for various structural configurations.*
GOAL AREA: III - RESPONSE CRITERIA					
Vibrations	Organize vibration-related projects, such as full-scale data collection, model tests, developing added mass characteristics, verification of analytical procedures, into a planned program.	*Correlate the proposed vibration-related projects program with the long-range planning document from SR-1259.*			

TABLE [illegible] (Continued)

Project Area	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986
GOAL AREA: III - RESPONSE CRITERIA (Continued)					
Vibrations (Continued)		*Prepare a program for developing and validating hull damping [illegible] procedures. (83-13)*			
			[illegible]	[illegible]	
	Develop a vibration-control guide for ship operators. (SR-1293)	[illegible]		[illegible]	
Stress-deformation analysis and prediction	Evaluate full-scale pressure measurement data from SP-1275.				
	Review ABS computer program pressure distribution calculations corresponding to SP-1271 model tests.				
		[illegible]	[illegible]		
		Assessment of the analysis methods for the non-linear reponse of marine structures to [illegible]	[illegible]		
	Develop instrumentation for ice breaker hull load measurements. (SP-1291)	Gather SP-1291 data.	Analyze SP-1291 data.		

TABLE I (Continued)

Project Area	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986
		GOAL AREA: III - RESPONSE CRITERIA (Continued)			
Stress-deformation analysis and prediction (Continued)			[illegible]	[illegible]	Generalize analytical model of ship-ice interaction to provide for high triaxial crushing strengths, high-strain rate, and irregular load distribution.
	Complete project developing procedure to measure shipboard strain rates. (SR-1285)	[illegible]			
		[illegible]	[illegible]		
		[illegible]	[illegible]	Evaluate results and prepare final specifications for system. [illegible]	
		GOAL AREA: IV - MATERIALS CRITERIA			
Fracture & fatigue control	Review the vulnerability of ship details under cyclic loading using the best available procedure. (SR-1257)	[illegible]	[illegible]		
				[illegible]	

TABLE I (Continued)

Project Area	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986
	GOAL AREA: IV - MATERIALS CRITERIA (Continued)				
Fracture & fatigue control (Continued)	Continue SR-1276 on long-term corrosion fatigue data in the design of offshore structures and ships and develop a long-term test plan.	Review program, [illegible] an initial [illegible] fatigue-control plan for offshore structures and ships.	[illegible] fatigue tests.	Continue testing, interim analysis.	Continue testing, interim analysis.
		Initiate project to determine the extent of damage [illegible] in ship structures [illegible] -4)	Continue with [illegible]	Review project results. If prior damage is detected, develop program for continued effort to quantify damage and service conditions where damage is important.	
	Critically review fracture-control plans for fixed offshore platforms which include material properties and designs for increased reliability in extreme marine environments. (SR-1288)	Review results and [illegible]	Initiate specific projects.	Continue effort.	
	Study ship fracture mechanisms in light of day's knowledge of fracture mechanics. (SR-1290)	Examine potential courses for future research and continue evaluation of new fractures.	[illegible]	Review safety analysis of ship structural details against fracture and fatigue failures. Develop reliability-based inspection and maintenance schedules to insure safety against brittle fracture.	Develop an overall fracture-control plan for ships that incorporates both fatigue and fracture behavior of fabricated ship details and a reliability analysis.

TABLE I (Continued)

Project Area	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986
		GOAL AREA: IV - MATERIALS CRITERIA (Continued)			
Corrosion control		Define data gathering requirements for corrosion data bank. [illegible]-7)	Complete program to define data gathering requirements for corrosion data bank.	Implement program to gather corrosion data (3 years). Prepare program to develop statistical approach to corrosion prediction.	Continue program to gather corrosion data. Contract and initiate program to develop statistical approach to corrosion prediction. Prepare program for analytic approach to residual strength prediction.
		GOAL AREA: V - FABRICATION TECHNIQUES			
Underwater welding	Examine performance of underwater and water-backed welds. (SR-1283)	Conduct necessary testing and evaluate program.	Review project results.		
Design of welded ship details	Develop a design guide for structural details that will assist designers in selection of sound, cost-effective details. (SR-1292)	Complete design guide for structural details.			
Influence of weld defects on integrity of marine structures		Determine influence of [illegible]	Determine influence of [illegible]	Continue studies, [illegible]	

TABLE 1 (Continued)

Project Area	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986
		GOAL AREA: V - FABRICATION TECHNIQUES (Continued)			
Effects of high deposition weld-improved HAZ	Identify critical controls & compositions in the development of improved weldments using high-deposition-rate processes and procedures. (SR-1256)	Conduct more detailed metallurgical examination of seven promising steel compositions. (SR-1256)	Complete metallurgical examination and recommend best composition to use for high-heat input welding. (SR-1256)	[illegible]	[illegible] in ship construction.
		GOAL AREA: VI - DETERMINATION OF FAILURE CRITERIA (RELIABILITY)			
Failure modes & safety analysis	Complete assessment and analysis of major uncertainties in current ship hull design procedures. (SR-1280)	[illegible]			
			Validate reliability in terms of failure probability or safety index for major failure modes of ships and other types of marine structures, designed according to current requirements.	Formulate a consistent reliability-based approach to design of marine structures against specific failure modes, such as overload, fracture and fatigue.	Specialize these criteria to specific applications, e.g., conventional ships and steels; mobile platforms; fixed platforms, advanced structural concepts and materials.
				Following Design Inspection Redundancy Symposium Workshop, initiate project to study mechanism of transfer of load & progressive failure in redundant parallel load path structures, considering such modes as buckling, fatigue, and fracture.	Synthesize results in terms of the influence of various initial imperfections and subsequent damage on reliability, considering the role of structural redundancy.
In-service monitoring	Develop the philosophy to do ship structural inspections. (SR-1289)	[illegible] floating offshore platforms.	[illegible] marine structures.	Develop formats for implementing [illegible] making rational decisions regarding repair, abandonment, or alternative protection measures.	Integrate these results with those from project area of Failure Modes and Safety Analysis.

TABLE I (Continued)

GOAL AREA: VII - DESIGN METHODS

Project Area	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986
Design procedures		*Examine SL-7 hatch-corner failure and document and compare experience with theoretical calculations. ([illegible])*			
			Consider need to develop procedure for predicting transverse plane motions and transverse and torsional loads.	*Fabricate large-scale hull girder model and test to failure, measuring stresses and deformations and comparing with calculations.*	*Evaluate possibility of using ultimate strength in hull girder design roles.*
			Develop preliminary design procedures for ends of ships to avoid vibration and slamming damage.	*Verify the preliminary design procedure for ends of ships.*	
	Complete supplementary monogram to SHIP STRUCTURAL DESIGN CONCEPTS. (SR-1263)				
	Examine minimum-size fillet welds for design. (SR-1236)	Evaluate fillet weld sizing results and suggest new guidelines. (SR-1286)			

FISCAL 1983 PROJECT RECOMMENDATIONS

Table II lists the projects proposed for the Fiscal Year 1983 Program, in priority order. It is based on the composite judgment of the SRC membership having considered the recommendations of the advisory groups. Prospectuses for each of these projects are presented following the table, in the same priority order.

As in past years, more projects are included than are likely to be funded with the anticipated support. However, the possibility of greater support, the need of the SSC for a reasonable number of projects from which to select, and the possibility that some projects not initiated in Fiscal Year 1983 could well be included in the program for the following year, suggest that the preparation of the additional prospectuses is a useful service.

The man-hour figures included in each prospectus are intended to indicate the approximate level of effort (cost) that is estimated to be required for completion of the project.

TABLE II-- RECOMMENDED PROJECTS FOR THE 1983 FISCAL YEAR

PRIORITY	PROJECT TITLE	PAGE
83-1	Design--Inspection--Redundancy Symposium/Workshop	29
83-2	Fatigue Prediction Analysis Validation From the SL-7 Hatch-Corner Strain Data	33
83-3	Development of an Onboard Strain Recorder	36
83-4	Structural Behavior After Fatigue	41
83-5	Development of a Generalized Onboard Response Monitoring System	43
83-6	Fatigue Characterization of Ship Details--Phase II	47
83-7	Corrosion Experience Data Bank	50
83-8	Influence of Weld Porosity on the Integrity of Marine Structures	53
83-9	Material Requirements for Advanced Marine Craft	55
83-10	Potential Impact of Automatic Fabrication and Inspection on the Integrity of Ship Structure	58
83-11	Assessment of the Analysis Methods for the Nonlinear Response of Marine Structures Subjected to Random Excitation	60
83-12	Model Tests for Pressure Distribution in Oblique Waves	64
83-13	Hydrodynamic Hull Damping	66

DESIGN--INSPECTION--REDUNDANCY SYMPOSIUM WORKSHOP

SRC PRIORITY 83-1

Long-Range Goal Area: Advanced Concepts and Long-Range Planning

OBJECTIVE

The objectives of this project are to examine the emerging technologies of ultimate strength and failure mode analysis, as applicable to marine structure systems; to delineate the most pressing problems; and to develop a detailed work plan.

BACKGROUND

For this project, "marine structural system" encompasses a set of integrated strategies which make up the design--inspection--redundancy triangle. The degree of fail-safe redundancy (multiple load paths) and element ductility which has been incorporated into the design of a structure has important implications in terms of its tolerance for flaws and/or overloads, and influences the strategies to be adopted for inspection and repair throughout its lifetime. Although each of the three types of structure (conventional ship hulls, fixed and floating offshore platforms) is subject to unexpected or premature failure by buckling, fatigue, or fracture, and many of their problems are generally similar, there are significant differences in the particulars and, thus, in the optimum strategies to be adopted.

Buckling failures of elements are influenced by the imperfections present, both those which are permitted during construction and those which are introduced in service due to slamming, minor collisions, etc. For tubular bracing elements and for shell and stiffener elements, peak capacity is maintained for only a

limited range of ductility, after which the element degrades and unloads. The overall strength and ductility of the structural system depends not only on these characteristics of the elements, but also on the ability of the system to accommodate the unloading of individual elements as they fail. This ability depends on the configuration of the system, which includes the degree of redundancy at each level or frame, as well as the degree of complexity.

Fatigue failure is also progressive, in terms of both crack growth in an individual element and load shedding from failed elements to intact elements in the system. Total fatigue life depends on the initial flaws permitted during construction. At some later time in the life of the structure, the remaining life can be related to the current state of fatigue damage. Again, the damage tolerance of the system, and the ability to detect damage depend on the configuration of the system.

Fracture control involves not only the selection of notch-tough materials, but also interrelated strategies for design, welding, inspection, and lifetime maintenance, appropriate to the structure's conditions of service and the consequences of its failure. Damage due to fatigue and repeated local buckling can lead to terminal failure by fracture. As with the other failure modes, the tolerance of the structure for flaws and isolated fractures is highly dependent on its degree of redundancy.

Many of these issues were discussed relative to conventional ship structures at the SRC-SNAME 1981 Extreme Loads Response Symposium. For example, the nonlinear analysis of Dow et al, an

Dowling's tests, indicate surprisingly little reserve strength, almost no flexural ductility, and rapid degradation for a model hull structure with relatively few parallel elements, while a second model with a higher degree of redundancy performed better.

Strategies for dealing with these aspects of fixed offshore platforms have been addressed by Marshall (1979 ISSC) by the USGS (Aerospace Corp. and Round Robin Projects), and by API and ASCE committees. Initial attempts have been made to develop practical measures of damage tolerance in terms of redundancy, and to relate detectability of damage to configurations. Techniques for nonlinear dynamic analysis of progressive collapse have been developed to deal with earthquake overloads.

Floating offshore platforms combine the stiffened plate construction of ship hulls with the tubular space frames of fixed platforms. However, the consequences of extending customary practices for design and inspection to a new form are sometimes not fully anticipated, as witnessed by the tragic failure of the Alexander Kielland hotel platform. A lack of structural redundancy contributed to this disaster.

Step-by-step tasks cannot be outlined at this time, nor is it likely that a single contractor can be found who can provide the considerable insight which is necessary in order to achieve the desired synthesis and meet these objectives. Thus, a workshop with invited participants is necessary to develop a focus and provide as much additional insight as can be obtained.

WORK SCOPE

The following tasks are considered necessary to meet the objective:

1. Establish a steering committee to develop a program for a coordinated series of position papers on relevant topics in the areas of ultimate strength, failure mode analysis, and strategies for the design--inspection--redundancy triangle, and to select participants to a working group. The program should focus on both common elements and differences of rationale applicable to:

   conventional ship hulls

   fixed offshore platforms

   mobile offshore platforms.

2. Arrange for preparation of papers to be presented in open session.

3. Arrange for three days of open sessions for approximately 250 people, where written discussion will be accepted, and extemporaneous oral discussion will be permitted as time allows.

4. Arrange for two days of closed sessions for a 30-participant group to consider the present status, to delineate the most pressing problems, and to develop a detailed work plan.

5. Include honorarium for three technical editors.

6. Arrange to have the full proceedings, with selected discussion and recommendations from the working group, to be published commercially at an early date.

MAN-HOURS

1000 -- Two-year period

FATIGUE PREDICTION ANALYSIS VALIDATION FROM THE SL-7 HATCH-CORNER STRAIN DATA

SRC PRIORITY 83-2

Long-Range Goal Area: Design Methods

OBJECTIVE

The objective of this project is to compare SL-7 hatch-corner fatigue cracking experience with theoretical fatigue calculations.

BACKGROUND

The need to publish well-documented case histories of service failures is well recognized. The SL-7 hatch-corner failure is perhaps unique in that it occurred in one of the most intensely analysed and instrumented ships afloat. Thus, with a relatively minor effort for data reduction and documentation, it could serve as an invaluable reference point for both designers and theoreticians.

The SEALAND McLEAN was delivered in 1972, and the first season of instrumentation was the winter of 1972-73. Although no hatch corner cracks were observed during this season, stain-gage data were obtained within 9-12 inches of the radius out of hatch corner No. 1.

During the second winter season, on December 19, 1973, a crack was discovered at hatch corner No. 1, after a severe storm. The strain-gage records bear the notation "Hove to, wind speed 100 knots, wave ht. (est.) 50 ft.," and show stress excursions of up to 51.4 ksi. The initiation site was covered by light plating, so that the crack was not visible until it had extended some 3-6 inches. During this same period, there was also green-water damage to the forecastle and flare plating.

The crack was welded, a new extension of the box girder was constructed, and additional strain gages were installed. Their output was recorded during the third season, 1974-75, during which time additional cracking occurred at the edge of the weld. During the 1975-76 season, a doubler was added locally, which also cracked.

The final fix was designed by ABS, who had performed both global and local finite element analyses of the ship structure and hatch corner. Additional data were recorded during the winter of 1977-78. No further cracking occurred.

WORK SCOPE

The following tasks are necessary in order to accomplish the objective of this project:

1. Briefly document the history of the SL-7, with particular emphasis on the circumstances attending the hatch-corner cracks in the McLEAN. The occurrence or non-occurrence of similar cracks in sister ships should also be noted.

2. Retrieve the ABS finite-element analyses, summarize results relevant to the site of cracking, and, if possible, relate local stresses to global loads and stresses.

3. Through the SSC, retrieve and then reduce strain-gage data for the vicinity of hatch corner No. 1. Using statistical methods to fill in any gaps, construct long-term cumulative stress distributions and histograms corresponding to the stress history leading up to each of the cracking incidents. The sequence of loading need not be retained. If appropriate, derive statistical parameters for the long-term distributions.

4. Make fatigue damage hindcasts for each of the cracking incidents, using the following methodologies:

a) Fracture mechanics, using published da/aN.

b) AWS & ASME hot spot S-N curves.

c) Munse's method of detail characterization.

5. To accommodate the well-known scatter in fatigue results, place the results in a probabilistic context, considering the SL-7 class as a sample population.

<u>MAN-HOURS</u>

1200 -- One year

DEVELOPMENT OF AN ONBOARD STRAIN RECORDER SRC PRIORITY 83-3
Long-Range Goal Area: Response Criteria

OBJECTIVE

The objective of this project is to develop an onboard strain recording instrument that will make use of state-of-the-art electronics to provide more useful engineering data than has been possible in the past.

BACKGROUND

The measurement of strain (stress) in actual ships at sea has been a long-sought goal of ship structural designers. Over recent years, a number of projects have been carried out which have made these measurements. Much, however, remains to be done and progress could be enhanced if the instrumentation could be improved. It appears likely that recent rapid progress in the miniturization and cost reduction of electronic sensing and recording equipment may have application here.

Past strain recordings on board ship have been made with the following types of equipment:

1. Scratch gage of the NCRE type: These gages were used on the SEA LAND McLEAN and other SL-7 ships. They recorded maximum strain range (+ and - strain reached) over some extended period of time such as four hours. The recording drum then advances and the maximum strain range over the next time period is recorded. One roll of chart is good for about three months. There is no information available as to the strain of a single cycle nor as to the number of times that

any value of strain was experienced. A battery powers the clock and advance mechanism.

2. Scratch gage of the brass disk type: This gage is completely mechanical. It records each strain cycle separately by scratching on a disk. The strain cycles are separated from each other by the advancing of the brass disk as each cycle is recorded. The disk will accommodate about two hundred or so stress cycles per revolution. If more cycles are recorded without changing the disk, they will be superimposed on each other. No recording is made of time. These gages are said to have been used in the SS MANHATTAN during testing in ice.

3. Electrical strain gages: These are bonded to the structure and are recorded on tape either locally or remotely. These systems can provide continuous strain readings and can include time signals and other data such as ship's course, wind speed, wave height, etc. They are quite versatile, but the strain readings have a tendency to drift over a period of time. The overall system tends to become expensive and to require frequent expert attention.

In an effort to develop a gage which will provide maximum data at minimum cost, it is envisioned that state-of-the-art electronics can be used to provide a package which will be rugged enough for shipboard service and which will record strain against time in a number of different configurations. Such a package might consist of the following components:

- watertight container to enclose the entire package with provision for bolting to the ship structure.

- linear variable displacement transformer (LVDT) to measure the $\pm$ elongation over the gage span (alternatively an electric strain gage may be used for this function)

- electronic mechanism to measure time on a basis of year, month, day, hour, minute and second (and possibly 1/100 second)

- battery

- microprocessor to manipulate the signals from LVDT and the clock

- recorder which will preserve simultaneous readings of clock and LVDT for future analysis

The recording of the data may be done in a number of different ways, such as:

1. Record the strain and the time once a second for a one minute duration once every hour. This will permit plotting several wave stress cycles. More frequent measurements would be useful for recording vibration.
2. Count the number of cycles where the Δ strain exceeds some given value. Several values of Δ strain may be used so that a histogram may be drawn. This will be useful in studying fatigue.
3. Record the one-second strain readings for a period of one minute after each time a given Δ strain in one cycle is measured.

4. Record the one-second strain readings for a period of one minute before each time a given Δ strain in one cycle is measured. This will require a continuous short-term memory function which will dump into the permanent record when triggered by a pre-selected Δ strain.

No doubt other, and perhaps more useful, recording configurations will emerge from a study of how the data may be used. The data should be stored in such a manner that it may be electronically processed and plotted.

The instrument should be capable of making useful strain records in connection with projects involving strain-rate measurements, still-water bending, slamming, structural bending, ice loads, episodic waves, fatigue measurements and vibration studies.

WORK SCOPE

The following tasks constitute the major efforts to be accomplished:

1. Identify the structural strain data needs which could plausibly be met by a self-contained, portable instrument package.

2. Write a description of its desirable characteristics and performance.

3. Design a strain vs. time recorder which meets the following requirements:

- fits the description of paragraph 1 above
- uses state-of-the-art electronics with static logic and static memory components

- self powered
- waterproof
- temperature compensated
- permanent zero-stress reference capability
- serviceable onboard by operations personnel
- affordable purchase cost and operating cost

4. Build a prototype

5. Make arrangements for a one-year onboard test of the prototype.

6. Carry out the test and analyse the results.

7. Make recommendations regarding necessary or desirable changes to the prototype.

8. Develop means to electronically analyse and plot the results of the recordings.

9. Analyse the one-year recordings.

10. Prepare a report containing instrument specifications, record of development problems and solutions, software for electronics data processing, instrument operating instructions and the results of the one-year test.

MAN-HOURS

2500 -- Over two to three years

STRUCTURAL BEHAVIOR AFTER FATIGUE SRC PRIORITY 83-4

Long-Range Goal Area: Materials Criteria

OBJECTIVE

The objective of this study is to determine whether or not damage is produced in ship plate by cyclic loading prior to the occurrence of readily visible cracks.

BACKGROUND

Damage tolerance is normally measured, either in terms of fatigue crack-growth rates or fracture toughness, by conducting laboratory tests on virgin (i.e., previously unstressed) metals. For structures in service, however, cracks may propagate into areas that were previously subjected to many cycles of stress below nominal yield.

If this prior cycling damaged the plate, then data collected on virgin plate would be non-conservative, and stress analyses based on these data would also be non-conservative. The purpose of this program is to determine whether or not prior cycling does decrease either the fracture toughness or fatigue crack-growth rate of ship steels. Emphasis is to be placed on the effect of prior cycling on crack-growth rate.

WORK SCOPE

The following tasks are to be accomplished:

1. Obtain and fatigue specimens by applying stress for a number of cycles of normalized ABS grade CS or D ship plate in the elastic regime. The number of fatigue cycles should be as large as practical for the applied stress-time pattern.

2. Conduct both fracture toughness and crack-growth rate tests on the prefatigued ABS ship plate and on virgin plate control specimens.

3. Measure prior damage in terms of changes in both fracture toughness and crack-growth rate, i.e., da/dN = F (K). Emphasis should be on the latter.

4. Write a report analyzing the results and the impact on service structural fitness of prefatigued, but uncracked, plates. This report should include specific recommendations for additional work if prior fatigue damage is found.

MAN-HOURS

2500 -- One year

DEVELOPMENT OF A GENERALIZED ON-BOARD RESPONSE MONITORING SYSTEM

SRC PRIORITY 83-5

Long-Range Goal: Response Criteria

OBJECTIVE

The objectives of this project are to develop a generalized operations-oriented stress and motion monitoring system, and implement it onboard three different types of vessels.

BACKGROUND

Numerous programs, sponsored by MarAd, USCG, ABS and others, have established the need for a hull stress and motion monitoring system. These same programs have also developed a number of systems (FURMAN-SMGS, LASH ITALIA-HWDAS, BURNS HARBOR-HSMGS, SO3) which, although tailored individually to a specific vessel type, have together contributed significantly to the knowledge and experience required to develop a generalized hull stress and motion monitoring system.

Design criteria and system specificatons are to be developed for a system to provide the deck officer and master with quantitative information on current and recent motions of the vessel, in order to supplement his "feel" of the vessel, and to call to the attention of the deck officer vessel response levels which the master deems significant. The intended system, should, to the greatest extent possible, be self-contained in a package suitable for location on the bridge. Cabling requirements should be kept to a minimum in order to make the system attractive as a retrofit item to ships already in service.

This generalized system is envisioned to incorporate a

limited number of sensors, at least one or two of which will be common to all systems. These common (standard) sensors might be limited to vertical motion at the bow and lateral acceleration. This will offer officers a common point of reference when moving from one vessel type to another.

At least one sensor will be at the owner/operator's choice, permitting customization for a specific vessel type. Additionally, consideration may be given to compatibility with possible future options such as a static loader, or a vessel motion guidance calculator.

In each of the previously mentioned programs, it has been reconfirmed that in order to effectively make use of the instruments, the deck officers must have a strong understanding of the rudiments of seakeeping. In order to achieve that, a course was developed and presented under sponsorship of the USCG. A second such course is currently under development in conjunction with the FURMAN test and evaluation program. It is expected that a refinement of these courses will be presented as an integral part of this project in addition to the training of the officers in the basic opeation of the system itself.

WORK SCOPE

The following tasks outline the scope of work which should be considered:

Phase I

1. Review current and past efforts at vessel instrumentation to produce design criteria for selection of the common and vessel

specific instrumentation for the new system.

2. Verify design criteria for the system through discussions with the owners, operators, classification societies, and experienced deck officers. Determine the availability of the selected sensors by canvassing domestic and foreign manufacturers of similar systems.

3. Generate specifications for the system, including both the common (standard) sensors, and a set of type-specific (optional) sensors, indicating relative costs for different levels of signal conditioning and presentation modes.

Phase II

1. Solicit owner/operators of three different vessel types who are willing to participate in the project and commit themselves to cost-share to a level which may equate to the cost of the hardware and installation.

2. Request proposals from manufacturers based on previously developed specifications, and select manufacturers.

3. Coordinate owner/operators with manufacturers on finalization of optional items in the specifications, and responsibilities for certification (if required) and installation of the system.

4. Provide training materials and instruction for the officers so they may develop the full potential of the system, including a structured introduction to ship handling in heavy weather.

5. Assume overall responsibility that the systems be installed and fully operational on-board in accordance with the finalized specifications. Maintenance is to be provided for the system during one year of vessel operation after installation.

6. Provide an observer for a number of voyages on-board each vessel to observe the use and understanding of the systems by the officers.

7. Provide for and report on technical evaluations of the systems as implemented.

8. Provide for and report on operators' evaluations describing suitability, reliability and confidence in the system.

9. Summarize the project in a final report including proposed revisions to the design criteria and/or system specifications based on the evaluations and conclusions.

REFERENCES

1. Chazal, E. A., et. al., "Status Report on the Application of Stress and Motion Monitoring in Merchant Vessels," 1980 Spring Meeting/STAR Symposium, SNAME, June 1980.

2. "A Description and Evaluation of a Proposed Hull Surveillance System," Veritas Report 79-0729, November 1979.

3. "Operator's Guide: BURNS HARBOR Hull Stress Monitoring and Guidance System," Hoffman Maritime Consultants Inc. Report, September 1980.

4. "Operator's Guide: USNS FURMAN Ship Response Monitoring and Guidance System," Hoffman Maritime Consultants Inc., July 1981.

MAN-HOURS

500 -- over 6 months - Phase I

3000 -- over 2 years - Phase II

FATIGUE CHARACTERIZATION OF SHIP DETAILS - PHASE II

SRC PRIORITY 83-6

Long-Range Goal Area: Materials Criteria

OBJECTIVE

The objective of this project is to extend SR-1257, further examine, analyze a test ship structural details and determine their influence on fatigue ,hich will ultimately lead to analytical procedures to evaluate and select fabricated ship details.

BACKGROUND

Ships under actual operating conditions are subjected to cyclic loading that initiate and propagate fatigue cracks at critical details. These cracks are usuallly detected and repaired, but occasionally may lead to severe damage and possible loss of life. There is a need to evaluate the behavior and useful life of fabricated ship details under cyclic-loading conditions that represent actual operating conditions for ships.

The various details used in the fabrication of ships have been catalogued in SSC-266 (Ref-1). Studies have also been performed to characterize the in-service performance of shipboard structural details (2,3). Work was initiated by Professor W. Munse of the University of Illinois, SR-1257-Fatigue Characterization of Fabricated Ship Details. This study was aimed at developing a design procedure to properly select ship details subjected to cyclic loading.

This study has provided a criterion to evaluate the fatigue resistance of welded details, together with a random loading and reliability factor necessary for the ship environment. This work also

resulted in actual fatigue data from tests performed on details with a high incidence of fatigue failures as reported in References 2 and 3.

The intent of the present study is to further extend and test the Munse criterion. Specifically, additional tests of problem details are required. This fatigue data should be used to further justify or amend the previous work.

WORK SCOPE

The following tasks are to be performed in this study:

1. Become thoroughly familiar with the Munse Fatigue Criterion Ref. (4). In addition, review previous shipboard fatigue experience Ref. (1,2,3) and statistical loading information.

2. Assess the Munse criteria and extend if indicated in light of any additional data or improved analytical methods.

3. Study and analyze the actual laboratory fatigue tests performed on fabricated ship details. Propose extending these tests to new or untested details which have presented in-service problems.

4. Perform actual fatigue tests on additional details which will further justify the previous analysis and be directly useful to a ship designer.

REFERENCES

1. Glasfeld, R. et al, "Review of Ship Structural Details," SSC-266, 1977.

2. Jordan, C.R., and C. S. Cochran, "In-Service Performance Of Structural Details," SSC-272, 1978.

3. Jordan, C. R. and L. T. Knight, "Further Survey Of In-Service Performance Of Structural Details," SSC-294, 1980.

4. Munse, W. H., "Fatigue Design Criteria For Ship Structure Details," to be published.

MAN-HOURS

1000 - First year

2000 - Second year

CORROSION EXPERIENCE DATA BANK SRC PRIORITY 83-7

Long-Range Goal Area: Materials Criteria

OBJECTIVE

The objective of this project is to design a data bank of corrosion rates upon which to eventually base a more rational approach for corrosion margins.

BACKGROUND

Corrosion is a major factor contributing to the eventual failure of a structure in a marine environment. Allowance for corrosion, in the form of added structural material, or retirement of the structure when its anticipated residual strength has reached a minimum acceptable level, has considerable economic significance. Significant economic benefits could be realized if replacement of a structure could be deferred and the life extended through a better understanding of the interaction between state of corrosion and residual strength. The first step in this understanding is better predictions of the extent of various types of corrosion, as a function of the particular vessel or type of vessel, and the service to which it is to be exposed.

Corrosion is affected by a large number of parameters and prediction of the extent of various types of corrosion, without undue conservatism, is considered best done statistically, using data acquired from actual ship operations. Large amounts of such data are available, in operators' records and files, but rarely is there

sufficient information on either the characteristics of the corrosion for residual strength analysis, or on all of the parameters that can affect various types of corrosion, for adequate corrosion prediction. Accordingly, a new program of corrosion data gathering is required, using a new vessel or fleet of vessels, and, in turn, the first step in this activity is to study how such a program should be conducted. An understanding is required of the type of data to be collected, the parameters to be recorded, and the type of documentation and instrumentation required. Such data collection will include: (a) corrosion details at various locations on the ship structure, but particularly strength critical areas; (b) data on the operation, such as route, speeds, sea conditions, time and location at dockside, cargo; (c) ship parameters, such as size, weight, structural materials, corrosion protection, etc.; and (d) ship history, including maintenance, repairs, etc.

Based on the results of this project, subsequent projects should include corrosion data gathering (requiring cooperation with a ship fleet operator); statistically based corrosion prediction, and an approach to residual strength prediction.

WORK SCOPE

The following tasks are considered essential to the project:

1. Review the work done under project SR 1269, "Internal Corrosion and Corrosion Control Alternatives."

2. Review other sources of information from ship owners and operators, U.S. Coast Guard and similar international bodies as well as appropriate industrial institutions. Determine the type of

corrosion data normally collected, the methods of collection and documentation used, the types of corrosion typically observed, and their relationship to critical areas of the structure.

3. Formulate a program of corrosion data collection, for the purpose of subsequently improving the prediction of corrosion significant to structural strength. Define the data required, the instrumentation required (if any), and the form of documentation.

4. Conduct interviews with selected ship operators to verify the practicality of the program developed under 3. Revise the program accordingly.

5. Prepare a report to present the results of the study, particularly defining corrosion data requirements and data gathering methodology. Make recommendations with respect to a data gathering program.

MAN-HOURS

1000 -- One year

INFLUENCE OF WELD POROSITY ON THE INTEGRITY OF MARINE STRUCTURES

SRC PRIORITY 83-8

Long-Range Goal Area: Fabrication Techniques

OBJECTIVE

The objective of this project is to define the dependence of the integrity of marine structures on weld porosity.

BACKGROUND

Over the past decade, considerable progress has been made in technologies used to assure the structural integrity of marine structures. These include new methods for stress and load analysis, fracture mechanics and improved nondestructive inspection (NDI) techniques. This continually developing body of knowledge needs to be applied to the assessment of the influence of many types of weld defects on the integrity of marine structures.

This project will consider only the influence of porosity. Other defects will be considered in the future. Considerable information (1) exists on the effect of porosity on the mechanical properties of weldments and on the ability of various NDI techniques to detect this type of flaw. This information needs to be incorporated into an independent analytical study to determine the functional dependence of the overall structural integrity on porosity. Once this dependence is quantified, the decision between flaw acceptability or the need for repair is facilitated in this regard. This dependence, based on a rational evaluation of the factors affecting integrity, could minimize unneeded repairs by expanding acceptance limits without adversely affecting the strength and durability of the structure.

WORK SCOPE

The following tasks are considered necessary to meet the objective:

1. Review and summarize available information on the influence of porosity on fatigue and fracture behavior of marine weldments.

2. Determine the functional dependence of the integrity of marine structures on weld porosity by conducting fracture-mechanics parametric studies using a fatigue stress spectrum and maximum credible stesses based on SL-7 and other ship load data banks, fatigue crack-growth data, and fracture-toughness data for materials used in ship construction. Limitations of currently available inspection techniques should be considered.

3. Prepare a report to present the results of the study. Recommend, where appropriate, new programs to meet the needs where insufficient information is available.

REFERENCES

1. Lundin, C. D., "The Significance of Weld Discontinuities/ A Review of Current Literature," WRC Bulletin 222, New York, 1976.

MAN-HOURS

2000 -- One year

MATERIAL REQUIREMENTS FOR ADVANCED MARINE VEHICLES

SRC PRIORITY 83-9

Long-Range Goal Area: Advanced Concepts and Long-Range Planning

OBJECTIVES

The objectives of this project are to determine material data requirements for use of the marine vehicle structural designer and to recommend a characterization program for the selected materials.

BACKGROUND

In the marine industry, there is a developing interest in reducing weight in marine vehicle structure and a corresponding interest in the use of structural materials of higher strength to weight ratio than conventional steels. Interest in their application includes a) displacement hulls, where high-strength steels offer benefits of increased payload which are modest but nevertheless significant over the life of the craft; b) crew boats and patrol craft with conventional planing hulls, where aluminum and composite materials, effectively used, offer reduced weight for increased speed and payload; c) hydrofoils, where high-strength steels and titanium alloys are essential in the foil systems, and d) surface-effect ships and air-cushion vehicles where aluminum alloys and composites in smaller craft and probably high-strength steels in large craft are essential to payload and speed; hence, their economic or military feasibility.

Materials of interest include high-yield-strength steels, aluminum alloys, stainless steels, titanium alloys and, in a more limited way, new material forms such as composites, and sandwich construction.

Most of these materials are a carryover from the aerospace industry. In the shipyards, however, more emphasis is placed on weldability, corrosion resistance, and heavier sections and less emphasis on quality control. As a consequence, the alloys used in the aerospace industry, and hence the extensive material characterization background built up by this industry for aircraft and space vehicle applications, are of limited use. There is, indeed, a great need for fatigue and fracture data for the particular alloys and material forms of interest to the marine industry. These include the effects of welding and joining, the effects of the marine environment, the effects of processing and inspection variables and the effects of local geometry of joining details.

WORK SCOPE

The following tasks are considered necessary to meet the objectives:

1. Selectively contact companies and agencies involved in development of high-performance marine vehicle to determine applications, resulting requirements imposed on structural materials, materials in use and the rationale behind their selection, and material characterization data required for more effective material application. Include in the consideration high-performance displacement vessels, SWATH (small water-plane twin hull) ships, air-cushion vehicles, surface-effect ships and hydrofoils. In particular, obtain the point of view of designers, who will use the material data, on the required characterization, in addition to the views of material specialists.

2. Review materials and their availability; examine strengths and weaknesses relative to marine requirements, and select two or three materials of potentially wide application for high-performance marine vehicle. Include in the review high-yield steels; high-strength, precipitation-hardened, stainless steels; titanium alloys; aluminum alloys; fiberglass reinforced plastics; and composites.

3. Define characterization data, including that for fatigue and fracture, required for the materials of interest. Define required material test programs, including both parent material and joined and fabricated assemblies. Include in the parameters to be considered the effects of environment, processing and joining, nondestructive inspection, geometric details, etc.

4. Prepare a report to present the results of the study and, in particular, make detailed recommendations for material-characterization programs, i.e. which tests are needed for which materials.

<u>MAN-HOURS</u>

1500 -- One year

POTENTIAL IMPACT OF AUTOMATIC FABRICATION AND INSPECTION ON THE INTEGRITY OF SHIP STRUCTURE — SRC PRIORITY 83-10

Long-Range Goal Area: Advanced Concepts and Long-Range Planning

OBJECTIVE

The objective is to assess the impact of integrating automated fabrication technologies and robotics with automated process control and nondestructive inspection (NDI) technologies on the integrity of marine structures.

BACKGROUND

Automated fabrication technologies and process controls are being introduced in shipbuilding operations to an ever increasing degree. These include the use of automated processes and robotics for handling, forming, cutting and welding of steel components. In addition, the advent of automated manufacturing has been helpful in attaining higher quality levels through more uniform control of processes and workmanship.

The effectiveness of this automation can be increased further by using automated, in-process monitoring of parameters that could affect the fitness-for-purpose of the component under fabrication. In particular, in addition to monitoring certain external process control parameters (e.g., temperature, current, dimensions, etc.), the material could be internally monitored for the presence of certain types of flaws. This may be particularly important in automated welding operatons involving thick-section structures.

In addition, this automation may also facilitate more reliable fabrication and inspection of complicated structures that are currently fabricated in several steps because the completed structure

may not be accessible to a human operator. Equally important, automatic processes may permit the completion of fabrication tasks while carrying out certain NDI procedures that may be hazardous or inaccessable to human operators.

WORK SCOPE

The following tasks are essential to complete the project:

1. Determine the state-of-the-art applications of automated fabrication and inspection technologies in the U.S. and abroad.

2. Identify areas which have directly benefited from the integration of automated fabrication technologies with automated process control and NDI technologies. For example, consider the use of automated welding in conjunction with robot manipulated radiographic and/or ultrasonic NDI instrumentation.

3. Assess impact on structural integrity, quality assurance, and safety.

4. Identify future developments that would influence the introduction of combined automated fabrication and inspection technologies in the shipyards.

MAN-HOURS

1500 -- One year

ASSESSMENT OF THE ANALYSIS METHODS FOR THE NONLINEAR RESPONSE OF MARINE STRUCTURES SUBJECTED TO RANDOM EXCITATION

SRC PRIORITY 83-11

Long-Range Goal Area: Response Criteria

OBJECTIVE

To survey available approaches for analyzing nonlinear response of marine structures under random excitation, and to provide statistical criteria for interpreting results in a consistent manner.

BACKGROUND

Ships and marine structures are subjected to random excitation by environmental elements, and there is a need for analyzing their response from a probabilistic approach. Existing formulations are generally applicable only to linear systems and the conditions for superposition must be valid. For the nonlinear state, equivalent methods of analysis are not as well developed, nor are criteria for evaluating the results.

Nonlinerarities may arise in both the loading and response of marine structures, for example:

1. Nonlinear drag force parameters, such as velocity-squared and relative motion.
2. Free surface effects such as member immersion/emergence, deck overflooding and slamming.
3. Large displacement in compliant structures, marine risers, and caternary moorings.
4. Nonlinear lift forces.
5. Material nonlinearities, such as plasticity and creep.
6. Geometric nonlinearities, such as postbuckling and large deflection.

7. Soil-structure interaction in bottom-supported marine structures.

8. Hydroelastic response, such as vortex shedding and strumming.

The need for considering nonlinear effects in the extremes of loading and response may be regarded as an integral part of a realistic ultimate strength and reliability evaluation, which must deal with all failure modes, even though the expected behavior may be more-or-less linear under normal conditions. Nonlinear time-domain dynamic-analysis computer programs have been developed to handle many of these problems. Some of these are specialized to a particular type of structure and loading. Even so, they are always complex and expensive to run; thus, some approach for reducing the complexity and time span covered by detailed analysis is generally taken. Approaches in use include, among others:

1. Selection of design wave based on statistics of the sea state (e.g., Longuet-Higgins), followed by deterministic analysis for this wave.

2. Conditional random wave simulation of a selected extreme event, based on recorded wave profile and hindcast directional spectrum.

3. Selection of one or more design segments of a random sea, based on full-storm (or voyage) duration screening analysis of a simplified representation of the structure, followed by a detailed analysis for the selected random wave time segments.

4. Random analysis for a representative time period followed by extrapolation to the extreme response using non-Gaussian statistics.

5. Nonlinear analysis in regular waves to establish transfer functions (which may vary with sea state) to be used in subsequent linearized analysis.

6. Analysis of a reduced model by one of the foregoing approaches, followed by application of the extreme forces to a more detailed model.

For most of these approaches, a statistical interpretation of the results is required; yet criteria for doing this are not well established. Some approaches yield variable results from multiple trials, and different approaches appear to yield inconsistent answers. Guidelines for selecting rational approaches and calibrating their results in terms of reliability are needed.

WORK SCOPE

The proposed project is to be primarily a philosophical/mathematical study. The following tasks are considered essential in meeting the objective:

1. Review the types of nonlinear behavior of interest for various classes of marine structures, together with the generic types of nonlinear physical models with which they are analyzed. This should be a limited task to plan the rest of the study in context.

2. Describe the probabilistic basis of selection of expected extreme loads and responses for structures.

3. Evaluate the various probabilistic, reliability and statistical approaches which may be taken for performing and interpreting nonlinear analysis, in terms of:

a) Their suitability for the various physical problems, available analytical models, and cost constraints

b) Their probabilistic interpretation, in terms of consistency with item (2) and with each other.

4. Describe consistent methodologies for selecting the modeling and analysis strategy for interpreting the results.

5. Prepare recommendations for further research.

6. Write a report directed to designers currently attempting to use this advanced technology.

MAN-HOURS

1000 -- Six months

MODEL TESTS FOR PRESSURE DISTRIBUTION IN OBLIQUE WAVES

SRC PRIORITY 83-12

Long-Range Goal Area: Response Criteria

OBJECTIVE

The objective of this project is to conduct tests of existing MV CORT and SL-7 models in oblique waves to measure hull pressures that will generate a data base for future computer program validation.

BACKGROUND

Full-scale pressure distribution measurements have been made on the MV CORT in both head seas and oblique waves. Models for the MV CORT and SL-7 ships have been constructed, instrumented and used in head sea tests. No model work has yet been done in oblique seas nor has a model vs. full scale in head seas correlation been made for the MV CORT.

The urgency for conducting the model tests is based on the present (but temporary) existence of the two instrumented models. These models would be run at various speeds and wave profiles at 45 degrees to the bow. The MV CORT model would, in addition, be run at conditions (speeds, wave profiles and wave directions) which correspond to full-scale runs for which hull pressure data are available. The results of these model runs and the correlations specified will provide a data base for the validation of future computer programs designed to predict hull surface pressures under wave action.

WORK SCOPE

The following tasks would comprise the major efforts to be accomplished:

1. Conduct tests of the existing MV CORT and SL-7 models at those various speeds and wave profiles at 45 degree of the bow which will permit correlation with existing head-sea tests for these models.

2. Conduct tests of the existing MV CORT model at those speeds, wave profiles and wave directions which will permit correlation with existing oblique wave full-scale test data for the MV CORT.

3. Make the following correlations:

a) Oblique wave MV Cort model test results with existing head wave MV CORT model test results.

b) Oblique wave SL-7 model test results with existing head wave SL-7 model test results.

c) Oblique wave MV CORT model test results with existing oblique wave MV CORT full-scale test results.

d) Existing head wave MV CORT model test results with existing head wave MV CORT full-scale test results.

4. Prepare and publish a final report of model test results and of the correlations outlined above. Information and data should be presented in a format suitable for use in the validation of computer programs which predict hull pressure distributions.

<u>MAN-HOURS</u>

2400 -- One year

HYDRODYNAMIC HULL DAMPING SRC PRIORITY 83-13

Long-Range Goal: Response Criteria

OBJECTIVE

The objective of the project is to prepare a program for the development and validation procedures for estimating the longitudinal distribution of energy dissipation (damping) associated with the principal flexural or "beam" modes of ship hull vibration.

BACKGROUND

Accurate calculation of the response of a ship's hull to low frequency dynamic excitation depends very strongly on the ability to calculate the energy dissipation caused by interaction between the hull and the water both by radiation and by viscous shear. This problem is particularly acute in the low-frequency range (0.5 to 10.0 Hz) associated with the free-free beam bending modes. While there is some small contribution from structural damping and a larger, variable amount due to cargo interaction, it is the hydrodynamic damping that must be principally relied on to control the vibration amplitude.

Up to now, the usual design practice has been to base this calculation on rigid hull motion. There is considerable evidence, mainly from model tests but some from full-scale tests of both naval and merchant vessels, that the amount of damping is greatly influenced by the hull flexibility.

The first phase of this study was the set of recommendations reported in SSC project SR-1261 "Hull Structural Damping Data." These recommendations require amplification.

The current proposal is a relatively modest one seeking an evaluation of experimental data readily available to the contractor.

From this information the contractor is expected to develop a specific program for using commercially available excitation equipment and instrumentation to obtain information necessary for a rational approach to the estimation of energy dissipation in beam bending modes of ships' hulls.

It is expected that this recommended program will have two more phases--Phase II will be the development of specific calculation procedures and the determination of appropriate numerical coefficients. Phase II may or may not require further model testing depending on the completeness of the information now available. Phase III will be verification of these procedures by full-scale tests.

WORK SCOPE

The following tasks are considered necessary to meet the objective:

1. List and evaluate test and analytical information related to beam bending hull damping from open reports and technical literature now in the contractor's files.

2. Based on this current information, define in specific terms a project for developing an analytical procedure for calculating the beam bending hull damping due to the interaction between the flexible hull and the water both at anchor and underway and write a work scope for the Phase II project. If further model tests are deemed necessary, they should be justified, and the specific test objectives and methods should be given.

3. Assuming successful completion of Phase II, develop a Phase III project for evaluation and verification of the Phase II

prediction methods by means of full-size tests and write a tentative Phase III work scope. The specific test conditions and methods are to be listed, together with specifications for commercially available testing equipment and instrumentation.

Among the topics to be explicitly specified in the work scope are:

a) Specific test conditions and methods.

b) Specifications for commercially available testing equipment and instrumentation.

c) Specific procedures for data reduction and presentation which will produce information useful in design.

d) Determination of appropriate and available ship types.

e) Appropriate operating conditions for the ships listed in Part d with some direct indication from ship operators that these tests could be run and that the operators would cooperate.

In addition to the above specific items, the final work scope statement must be in such detail that it can be used as the technical basis for preparing a Request for Proposals.

4. Estimate, separately, the man-hour effort necessary for Phases II and III with whatever supporting detail is appropriate.

<u>MAN-HOURS</u>

500 -- Six months

REVIEW OF ACTIVE AND PENDING PROJECTS

This section of the report covers current projects funded with FY 1981 (or earlier) funds, others that have been continued with FY 1982 funds, and those which are anticipated to be supported with FY 1982 funds. These projects, listed in Table III, constitute the current program. The majority of projects are for one-year's duration; multiyear projects are funded incrementally on an annual basis.

Project descriptions, including the SR project number and title, the name of the principal investigator and his organization, where these have been determined, and the activation date and funding, where applicable, are provided. The appropriate SSC Long-Range Goal is also noted, and a very brief statement of the objective of each project is given. These are followed by a short description of the present status of the project.

This format does not permit a detailed or comprehensive description of individual projects; however, each project included will normally result in one or more SSC reports.

<u>TABLE III -- REVIEW OF ACTIVE AND PENDING PROJECTS</u>

SR-NO.	PROJECT TITLE	PAGE
SR-1256,	"Investigation of Steels for Improved Weldability in Ship Construction"	71
SR-1270,	"Survey of Experience Using Reinforced Concrete in Floating Marine Structures"	72
SR-1276,	"Long-Term Corrosion Fatigue of Welded Marine Steels"	73
SR-1277,	"Advanced Method for Ship-Motion and Wave-Load Predictions"	74
SR-1280,	"Analysis and Assessment of Major Uncertainties in Ship Hull Design"	75
SR-1281,	"Ship Structures Loading in Extreme Waves"	76
SR-1282,	"In-Service Still-Water Bending Moment Determination"	77
SR-1283,	"Performance of Underwater Weldments"	78
SR-1284,	"Liquid Slosh Loading in Cargo Tanks"	79
SR-1285,	"Determination of the Range of Shipboard Strain Rates"	80
SR-1286,	"Fillet Weld Strength Parameters for Shipbuilding"	81
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SR-1290,	"Ship Fracture Mechanisms Investigation"	85
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SR-1294,	"Calculation Aids for Predicting Grounded Ship Responses"	89
SR-1295,	"Full-Scale Slam Instrumentation and Wavemeter Data Collection"	90
SR-1296,	"Long-Range Research Plan Review"	91

PROJECT NO.: SR-1256
PROJECT TITLE: INVESTIGATION OF STEELS FOR IMPROVED WELDABILITY IN SHIP CONSTRUCTION
INVESTIGATOR: Dr. L. F. Porter
CONTRACTOR: U.S. Steel Corporation, Monroeville, PA
ACTIVATION DATE: September 29, 1978
CONTRACT FUNDING: $318,064
SSC LONG-RANGE GOAL: DOT-CG-80588-A

OBJECTIVE

The objective of this multi-year study is to select the optimum materials and welding parameters to improve resistance to degradation of the heat-affected-zone (HAZ) properties in weldments made with high-deposition rate processes.

STATUS

As a result of an exploratory testing program on three production heats of steels and twenty laboratory heats, more detailed study of the microstructural features of the HAZ's and an analysis of the mechanisms responsible for good and poor performance in seven of these steels is now underway. It is anticipated that 21 months will be required to do this work.

PROJECT NO.:	SR-1270
PROJECT TITLE:	SURVEY OF EXPERIENCE USING REINFORCED CONCRETE IN FLOATING MARINE STRUCTURES
INVESTIGATOR:	Dr. O. H. Burnside
CONTRACTOR:	Southwest Research Institute, San Antonio, TX
ACTIVATION DATE:	November 26, 1979
CONTRACT FUNDING:	$41,252
SSC LONG-RANGE GOAL:	Advanced Concepts and Long-Range Planning
CONTRACT NUMBER:	DOT-CG-919837-A

OBJECTIVE

The objective of this project is to assess the state-of-the-art for reinforced concrete, including prestressed and conventionally reinforced concrete, applicable to floating marine structures.

STATUS

A draft final report is being prepared.

PROJECT NO:	SR-1276
PROJECT TITLE:	LONG-TERM CORROSION FATIGUE OF WELDED MARINE STEELS
INVESTIGATOR:	Dr. O.H. Burnside
CONTRACTOR:	Southwest Research Institute, San Antonio, TX
ACTIVATION DATE:	September 29, 1980
CONTRACT FUNDING:	$144,810
SCC LONG-RANGE GOAL:	Materials Criteria
CONTRACT NUMBER:	DTCG23-80-C-20028

OBJECTIVE

The objective of the research is to define and evaluate currently available technology for assessing the long-term corrosion fatigue behavior of welded joints in sea water; and to develop a plan for long-term future efforts, if required.

STATUS

Data have been collected on long-term corrosion parameters applicable to welded joints in seawater, and a critical review of them is being performed. Efforts are also being directed toward preparing a design methodology that will incorporate several procedures, such as da/dN and notch stresses. However, complex analytical procedures are being avoided so as not to divert attention from the critical review and long-term planning aspect of the project.

PROJECT NO:	SR-1277
PROJECT TITLE:	ADVANCED METHOD FOR SHIP-MOTION AND WAVE-LOAD PREDICTIONS
INVESTIGATOR:	Mr. J.C. Oliver
CONTRACTOR:	Giannotti and Associates, Inc., Annapolis, MD
ACTIVATION DATE:	September 29, 1980
CONTRACT FUNDING:	$99,534
SSC LONG-RANGE GOAL:	Loads Criteria
CONTRACT NUMBER:	DTCG23-80-C-20032

OBJECTIVE

The objective of the study is to develop a method and appropriate computer program for predicting ship motions and distributed wave loads, taking into account the hull form shape above and below the still waterline, including the three-dimensional hydrodynamic coefficients.

STATUS

A detailed approach for a time-domain method, using a strip theory approach, coupled with a three-dimensional numerical model for the bow region has been reviewed. Ship motions and loads in five degrees of freedom are computed in response to a multi-directional irregular linear wave system by using an extended strip formulation. Forces and responses from nonlinear unidirectional waves can then be computed using the above detailed approach. However, additional detailed information is being prepared to assure the soundness of the approach before developing the computer program.

PROJECT NO:	SR-1280
PROJECT TITLE:	ANALYSIS AND ASSESSMENT OF MAJOR UNCERTAINTIES IN SHIP HULL DESIGN
INVESTIGATOR:	Dr. P. Kaplan
CONTRACTOR:	Hydromechanics, Inc., Plainview, NY
ACTIVATION DATE:	June 8, 1981
CONTRACT FUNDING:	$23,850
SSC LONG-RANGE GOAL:	Determination of Failure Criteria (Reliability)
CONTRACT NUMBER:	DTCG 23-81-C-20006

OBJECTIVE

The objective of the study is to identify the major sources of uncertainties underlying the design of ship hull structures.

STATUS

In the area of loads, consideration is being given to the nature of the distribution of amplitudes of bending moments in regard to their basic statistical characteristics, and to the possible influence of nonlinearities that arise due to hull shape variations.

Efforts to establish some measure of the magnitude of the slam forces acting on the bow disclose a relatively difficult means of representing the probability characteristics of the slam force, aside from the determination of the amplitude properties. Therefore, efforts to do this are being discontinued.

The major aspect of uncertainty being investigated for ultimate strength is the establishment of the variability of strength in the compression flange. Methods are also being considered to establish means of analysis for the different structural components with the major problem being on how to combine the evaluation of the component characteristics with the treatment of the way that the various components interact.

PROJECT NO:	SR-1281
PROJECT TITLE:	SHIP STRUCTURES LOADING IN EXTREME WAVES
INVESTIGATOR:	Mr. W.H. Buckley
CONTRACTOR:	David Taylor Naval Ship Research and Development Center, Carderock, MD
ACTIVATION DATE:	August 18, 1981
CONTRACT FUNDING:	$30,050
SSC LONG-RANGE GOAL:	Loads Criteria
CONTRACT NUMBER:	MIPR Z 70099-1-07143

OBJECTIVE

The objective of the study is to examine the possibility of a ship encountering some kinds of extreme waves and to understand the significance of this in ship structural design.

STATUS

Several case histories covering a modern high-speed containership and container/barge ship damage have been examined in detail and correlated with specific extreme waves. Contacts with ship masters and Coast Guard officers, serving on weather ships, have disclosed other unusual waves that occur frequently and under certain conditions.

Modelling extreme waves that occur once in a wave train of smaller waves in a tank has not been possible, so correlations with model data have not been possible. Nor has a data bank citing when extreme waves have occurred been developed. Further, most of the ships examined have been very large. This has been attributed to a paucity of data for smaller ships.

Efforts are now being concentrated on the few cases where the ship and oceanographic data are sufficient to provide in-depth examinations.

PROJECT NO:	SR-1282
PROJECT TITLE:	IN-SERVICE STILL-WATER BENDING MOMENT DETERMINATION
INVESTIGATOR:	Dr. J.G. Giannotti
CONTRACTOR:	Giannotti & Associates, Inc., Annapolis, MD
ACTIVATION DATE:	November 9, 1981
CONTRACT FUNDING:	$31,210
SSC LONG-RANGE GOAL:	Loads Criteria
CONTRACT NUMBER:	DTCG 23-82-C-20002

OBJECTIVE

The objective of the study is to develop a plan to obtain in-service still-water loading data.

STATUS

Interviews with designers, builders, owners, operators and classification societies have been conducted to determine methods and their effectiveness to controll the still-water bending moment (SWBM), and to determine the willingness of owners and operators to participate in a research program to record loading conditions and/or to measure stresses with instrumentation. Based on the outcome of these interviews, it should be possible to identify the ship types which have specific significant SWBM problems. Concurrently, the relative cost and effectiveness of various methods of obtaining SWBM service data based on operational experience will be evaluated. Following this, strategies for recording loads and stresses are to be developed to provide sufficient information for a probability-based design method.

PROJECT NO: SR-1283
PROJECT TITLE: **PERFORMANCE OF UNDERWATER WELDMENTS**
INVESTIGATOR: Unknown
CONTRACTOR: Unknown
ACTIVATION DATE: Unknown
CONTRACT FUNDING: 4500 man-hours (Two-year project)
SSC LONG-RANGE GOAL: Fabrication Techniques
CONTRACT NUMBER: DTCG-23-81-R-20020

OBJECTIVE

The objectives of the proposed research are to gather data on the mechanical properties on wet and wet-backed underwater weldments and to provide guidelines relating these properties to design performance.

STATUS

Proposals have been evaluated and contract negotiations are underway.

PROJECT NO:	SR-1284
PROJECT TITLE:	LIQUID SLOSH LOADING IN CARGO TANKS
INVESTIGATOR:	Unknown
CONTRACTOR:	Unknown
ACTIVATION DATE:	Unknown
CONTRACT FUNDING:	3500 man-hours (Two-year project)
SSC LONG-RANGE GOAL:	Loads Criteria
CONTRACT NUMBER:	DTCG-23-81-R-20024

OBJECTIVE

The objective of this study is to determine sloshing loads, for liquids of specific gravities ranging from 0.4 to 1.8 and typical enroute service viscosities, on the boundaries, swash bulkheads and internal framing of partially filled tanks of various proportions.

STATUS

Proposals have been evaluated and contract negotiations are underway.

PROJECT NO:	SR-1285
PROJECT TITLE:	DETERMINATION OF THE RANGE OF SHIPBOARD STRAIN RATES
INVESTIGATOR:	Dr. J.G. Giannotti
CONTRACTOR:	Giannotti & Associates, Inc., Annapolis, MD
ACTIVATION DATE:	September 17, 1981
CONTRACT FUNDING:	$28,502
SSC LONG-RANGE GOAL:	Response Criteria
CONTRACT NUMBER:	DTCG-23-81-C-20028

OBJECTIVE

The objective of this project is to develop a test program to obtain representative strain rates in ship hull structures.

STATUS

Preliminary observations and calculations indicate it is feasible to obtain strain-rate information from existing ship instrumentation programs. But, in all cases, the data have to be reanalyzed before detailed information may be obtained directly. Also, there are significant gaps in the data bases for collision-induced strain rates. Two methods available that may fill the gaps are: a) obtaining the strain-rate information from analytical simulations, or b) obtaining new strain-rate data. A cost-benefit analysis will be conducted to determine the best possible method. In addition, two generic methods will be outlined for determining the representative ranges of strain rates for ship types that have not been instrumented.

PROJECT NO:	SR-1286
PROJECT TITLE:	FILLET WELD STRENGTH PARAMETERS FOR SHIPBUILDING
INVESTIGATOR:	Mr. C.R. Jordan
CONTRACTOR:	Newport News Shipbuilding and Drydock Company, Newport News, VA
ACTIVATION DATE:	September 29, 1981
CONTRACT FUNDING:	$49,980
SSC LONG-RANGE GOAL:	Design Methods
CONTRACT NUMBER:	DTCG-23-81-C-20030

OBJECTIVE

The objective of this project is to discover areas in the ship where fillet weld sizes may be safely reduced below current practices and to estimate the saving in construction cost from such reductions.

STATUS

Work has begun on developing two formulas which would equate the ultimate weld strength to that of the base material. One will apply to loading that produces longitudinal shear in the weld, and the other will apply to loading which produces transverse shear. Sufficient experimental results are available to validate the constants used in these formulas. Once the weld-size formulas and joint efficiencies have been established, they will be applied to three different ships and the results compared to those using direct application of the existing ABS Rules. Finally, a cost analysis will be performed and then a means for incorporating the new fillet weld sizing method in existing commercial ship construction rules and regulations will be offered.

PROJECT NO:	SR-1287
PROJECT TITLE:	JOINT OCCURRENCE OF ENVIRONMENTAL DISTURBANCES
INVESTIGATOR:	Mrs. S.L. Bales
CONTRACTOR:	David Taylor Naval Ship Research and Development Center, Carderock, MD
ACTIVATION DATE:	November 30, 1981
CONTRACT FUNDING:	$75,000 + $20,000 Navy supplement
SSC LONG-RANGE GOAL:	Loads Criteria
CONTRACT NUMBER:	MIPR-Z 70099-2-00919

OBJECTIVE

The objective is to develop a method and a representative data bank, useful for design, that identifies the simultaneous occurrence of winds and directional wave spectra.

STATUS

This activity has coalesced with ongoing Navy work to make Navy hindcast data available in a usable form to the entire marine design community. Government and commercial groups are being surveyed informally to determine current design practice, additional requirements, deficiencies, parameter resolution, and environmental needs. Further efforts are being undertaken to construct the following frequency of occurrence statistics:

a. significant wave height versus modal wave period

b. significant wave height versus zero crossing period

c. significant wave height versus wind speed

d. significant wave height versus primary wave direction

e. wind speed versus wind direction

f. wind direction versus primary wave direction (for given wind and sea severities)

g. modal wave period versus zero crossing period

PROJECT NO: SR-1288
PROJECT TITLE: FRACTURE CONTROL FOR FIXED OFFSHORE STRUCTURES
INVESTIGATOR: Unknown
CONTRACTOR: Unknown
ACTIVATION DATE: Unknown
CONTRACT FUNDING: 1000 man-hours
SSC LONG-RANGE GOAL: Materials Criteria
CONTRACT NUMBER: Unknown

OBJECTIVE

The objective of this study is to examine critically the technology and practices that constitute the fracture-control plans used by designers, builders and operators of fixed offshore structures.

STATUS

Proposals have has been evaluated and contract negotiations are underway.

PROJECT NO:	SR-1289
PROJECT TITLE:	STRUCTURAL INSPECTION GUIDELINES
INVESTIGATOR:	Mr. N.S. Basar
CONTRACTOR:	M. Rosenblatt & Son, Inc., New York, NY
ACTIVATION DATE:	September 30, 1981
CONTRACT FUNDING:	$50,878
SSC LONG-RANGE GOAL:	*Determination of Failure Criteria (Reliability)*
CONTRACT NUMBER:	DTCG 23-81-C-20036

OBJECTIVE

The objective of this study is to develop a guide that will set forth a coherent philosophy toward structural inspection for use of marine people involved in designing, building, accepting, and operating ships.

STATUS

A literature review is underway, the results of which will be used as a starting point for interviews and surveys. The three basic subject categories of structural design, construction, and inspection practices will be addressed during this process and their relationships to each other will be considered. In-service inspections of a minimum of four ships will be witnessed by an investigating team in order to document current periodic inspection practices. Then, the results of the review, surveys, and investigations will be screened and analyzed to identify weaknesses and to formulate the structural inspection guide.

PROJECT NO:	SR-1290
PROJECT TITLE:	SHIP FRACTURE MECHANISMS INVESTIGATION
INVESTIGATOR:	Unknown
CONTRACTOR:	Unknown
ACTIVATION DATE:	Unknown
CONTRACT FUNDING:	3500 man-hours (three-year project)
SSC LONG-RANGE GOAL:	Materials Criteria
CONTRACT NUMBER:	Unknown

OBJECTIVE

The objectives of this study are to examine current and future ship fractures over a period of years, to examine past ship fractures in the light of present understanding, and to catalog and assess the types of fractures that occur in ship structures.

STATUS

A proposal request has been prepared.

PROJECT NO:	SR-1291
PROJECT TITLE:	ICE LOADS AND SHIP RESPONSE TO ICE
INVESTIGATOR:	To be named
CONTRACTOR:	ARCTEC, Incorporated, Columbia, MD
ACTIVATION DATE:	Unknown
CONTRACT FUNDING:	8300 man-hours (three-year project)
SSC LONG-RANGE GOAL:	Loads Criteria
CONTRACT NUMBER:	Unknown

OBJECTIVE

The objective of this project is to measure ice pressure through the measurement of structural deflections of selected portions of the hull plating on the POLAR Class Icebreaker to develop ice load and response criteria for various types of ice.

STATUS

A sole-source proposal is being prepared to interface with an ongoing project sponsored jointly by the Maritime Administration, the U.S. Coast Guard, the State of Alaska, the Canadian Government, and U.S. oil companies.

PROJECT NO:	SR-1292
PROJECT TITLE:	SHIP STRUCTURAL DETAIL DESIGN GUIDE
INVESTIGATOR:	Unknown
CONTRACTOR:	Unknown
ACTIVATION DATE:	Unknown
CONTRACT FUNDING:	2000 man-hours
SSC LONG-RANGE GOAL:	Design Methods
CONTRACT NUMBER:	Unknown

OBJECTIVE

The objective of this study is to develop a design guide for structural details that will assist designers in the selection of sound, cost-effective details.

STATUS

A proposal request has been prepared.

PROJECT NO: SR-1293
PROJECT TITLE: GUIDE FOR SHIPBORAD VIBRATION CONTROL
INVESTIGATOR: Unknown
CONTRACTOR: Unknown
ACTIVATION DATE: Unknown
CONTRACT FUNDING: 1000 man-hours
SSC LONG-RANGE GOAL: Design Methods
CONTRACT NUMBER: Unknown

OBJECTIVE

The objective of this project is to develop a vibration-control guide which will serve as a useful tool in the hands of ship operators, shipyards, and others who must deal with ship-vibration problems but who have limited knowledge and experience in the field.

STATUS

A proposal request has been prepaied.

AD-A112 856 NATIONAL RESEARCH COUNCIL WASHINGTON DC SHIP RESEARCH--ETC F/G 13/10
REVIEW AND RECOMMENDATIONS FOR THE INTERAGENCY SHIP STRUCTURE C--ETC(U)
MAR 82 DTCG23-81-C-20044

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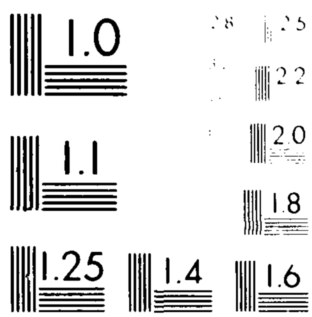
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2.8
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PROJECT NO:	SR-1294
PROJECT TITLE:	CALCULATION AIDS FOR PREDICTING GROUNDED SHIP RESPONSES
INVESTIGATOR:	Unknown
CONTRACTOR:	Unknown
ACTIVATION DATE:	Unknown
CONTRACT FUNDING:	2000 man-hours
SSC LONG-RANGE GOAL:	Loads Criteria
CONTRACT NUMBER:	Unknown

OBJECTIVE

The objective of this project is the development of specifications for calculation aids for the assessment of damage, stability, and survivability of grounded vessels.

STATUS

A proposal request has been prepared.

PROJECT NO:	SR-1295
PROJECT TITLE:	FULL-SCALE SLAM INSTRUMENTATION AND WAVEMETER DATA COLLECTION
INVESTIGATOR:	Mr. A.L. Disenbacher
CONTRACTOR:	David Taylor Naval Ship Research and Development Center, Carderock, MD
ACTIVATION DATE:	Unknown
CONTRACT FUNDING:	5000 man-hours (three-year period)
SSC LONG-RANGE GOAL:	Loads Criteria
CONTRACT NUMBER:	Unknown

OBJECTIVE

The objective of this project is to instrument a particular vessel with the intent to correlate the recorded slam data with model and analytical predictions for this particular vessel.

STATUS

A sole-source proposal is being prepared.

PROJECT NO:	SR-1296
PROJECT TITLE:	LONG-RANGE RESEARCH PLAN REVIEW
INVESTIGATOR:	Mr. E.M. MacCutcheon
CONTRACTOR:	E. M. MacCutcheon, Consultant
ACTIVATION DATE:	November 1, 1981
CONTRACT FUNDING:	$18,000
SSC LONG-RANGE GOAL:	Advanced Concepts and Long-Range Planning
CONTRACT NUMBER:	ABS Grant

OBJECTIVE

The objective of this project is to review the work of Project SR-1259, "A Long-Range Research Program in Ship Structures" and put it into the perspective of what the SSC objectives should be for the next twenty years.

STATUS

Efforts have been started toward defining the format of the results; reviewing scenarios from the SR-1259 study; identifying the key technological, political, social and institutional trends; formulating a sequenced ship structure research plan, including major thrusts or programs as required; and justifying the selected thrusts.

It is anticipated that a draft report will be available by early April, 1982.

REVIEW OF COMPLETED PROJECTS

The projects completed since the last annual report are listed below. Project descriptions, similar to those for the active program, follow. Reports from these projects have either been published or are at present in the publication process and the final SSC reports can be expected in the near future.

SR-1245, "Reduction of SL-7 Scratch-Gage Data"

SR-1257, "Fatigue Characterization of Fabricated Ship Details"

SR-1259, "A Long-Range Research Program in Ship Structures"

SR-1261, "Hull Structural Damping Data"

SR-1263, "Ship Structural Design Concepts--Part II"

SR-1269, "Internal Corrosion and Corrosion-Control Alternatives"

SR-1271, "Pressure Distribution Model Tests in Waves"

SR-1275, "Full-Scale Pressure Distribution Measurements of MV S.J. CORT"

SR-1279, "SL-7 Program Summary, Conclusions and Recommendations"

The following project was not undertaken for the reason cited in the project description:

SR-1272, "Computer-Aided Procedure for Calculating Grounded Ship Resources"

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PROJECT NO:	SR-1245
PROJECT TITLE:	REDUCTION OF SL-7 SCRATCH-GAGE DATA
INVESTIGATOR:	Mr. E. T. Booth
CONTRACTOR:	Teledyne Engineering Services, Waltham, MA
ACTIVATION DATE:	March 1977
CONTRACT FUNDING:	$88,511
SSC LONG-RANGE GOAL:	Response Criteria
CONTRACT NUMBER:	DOT-CG-61712-A & 844331-A

OBJECTIVE

The objective is to obtain and reduce two additional years of scratch-gage records from eight SL-7 containerships to usable form and to compare these data with electrical strain-gage data obtained aboard the SL-7 SEA-LAND McLEAN.

RESULTS

Over 53,000 measurable readings of midship bending stress have been tabulated and presented in histogram form. A review of the histograms indicates that very few stress events exceeded 20,000 psi. The maximum scratch-gage recording was 37,950 psi on the SEALAND McLEAN. During the same interval, the electrical strain gage indicated a maximum peak-to-trough stress of 53,600 psi. Fortunately, the investigator was aboard at the time and observed that the high-strain reading was the result of one wave cycle occurring very rapidly. The scratch gage, due to its mechanical operation, probably could not respond fast enough to have measured the total stress. Other than this particular instance, comparisons of the data show that the scratch gage on the McLEAN measures the extreme stresses experienced with reasonable accuracy.

PROJECT NO: SR-1257
PROJECT TITLE: FATIGUE CHARACTERIZATION OF FABRICATED SHIP DETAILS
INVESTIGATOR: Prof. W.H. Munse
CONTRACTOR: University of Illinois, Urbana, IL
ACTIVATION DATE: November 30, 1978
CONTRACT FUNDING: $95,016
SSC LONG-RANGE GOAL: Materials Criteria
CONTRACT NUMBER: DOT-CG-823899-A

OBJECTIVE

The objective of this multi-year study is to classify ship details in terms of their behavior and useful life under cyclic-loading conditions.

RESULTS

A simple design procedure has been developed to provide for fatigue strength verification in ship design where the criteria provide for:

a. A large variety in ship structure details

b. The *basic fatigue resistance* of numerous welded details

c. A distribution function that can be used to represent the long-life loading (10^8 cycles--20 years) for various types of ships

d. A random loading factor that accounts for the randomness of the loading during the life of the structure

e. A relability factor (factor of safety) that accounts for the many uncertainties that exist.

PROJECT NO:	SR-1259
PROJECT TITLE:	A LONG-RANGE RESEARCH PROGRAM IN SHIP STRUCTURES
INVESTIGATOR:	Mr. J.J. Hopkinson
CONTRACTOR:	Gibbs & Cox, Inc., Arlington, VA
ACTIVATION DATE:	January 31, 1979
CONTRACT FUNDING:	$226,320
SSC LONG-RANGE GOAL:	Advanced Concepts and Long-Range Planning
CONTRACT NUMBER:	DOT-CG-80371-A

OBJECTIVE

The objective of this multi-year study is to develop a marine structures planning document directed toward, but not limited to, the technical goals and charter of the Ship Structure Committee, and to forecast the research and development needs, based on a system of priorities, for the next 20 years.

RESULTS

The results from this project are now being reviewed and condensed in a form suitable for publication under project SR-1296, "Long-Range Research Plan Review."

PROJECT NO: SR-1261
PROJECT TITLE: HULL STRUCTURAL DAMPING DATA
INVESTIGATOR: Mr. T.P. Carroll
CONTRACTOR: Carroll Associates, Bethesda, MD
ACTIVATION DATE: March 12, 1979
CONTRACT FUNDING: $21,733
SSC LONG-RANGE GOAL: Design Methods
CONTRACT NUMBER: DOT-CG-824267-A

OBJECTIVE

The objective of this study is to collect and evaluate available structural damping data applicable to ship vibration analysis, and to recommend an experimental program, model or full scale, to expand and verify the design data.

RESULTS

A literature survey discusses available data for ship vibration damping, and assesses analytical and experimental techniques used in the past. Based upon this review, an experimental method is presented to isolate the damping coefficients associated with each important mode of vibration, as well as the breakdown of the total damping into its separate components (structural, cargo, and hydrodynamic), and to determine the distribution of the damping along the ship. In addition, a program of full-scale and model experiments for the determination of hull damping coefficients is outlined. However, the recommendations are insufficiently quantitative to form the basis for an ongoing program.

PROJECT NO: SR-1263
PROJECT TITLE: SHIP STRUCTURAL DESIGN CONCEPTS - PART II
INVESTIGATOR: Dr. J.H. Evans
CONTRACTOR: J.H. Evans, Lexington, MA
ACTIVATION DATE: March 1, 1978
CONTRACT FUNDING: $29,000
SSC LONG-RANGE GOAL: Design Methods
CONTRACT NUMBER: DOT-CG-80358-A

OBJECTIVE

The objective of this two-year study is to prepare a supplementary monograph to the Ship Structural Design Concepts published in 1974.

RESULTS

All seven chapters have been reviewed by a panel of the SNAME Hull Structure Committee. The Chapter titles are:

1. Shear Stresses Due to Bending,
2. Torsion,
3. Hull-deckhouse Interaction,
4. Principal Stresses (and Extent of Unreduced Scantlings),
5. Hull Girder Deflections and Stiffness,
6. Full-Scale Longitudinal Strength Experiments, and
7. Preliminary Choice of Framing Systems and Hull Girder Proportions (and Hull Synthesis in the Presence of Bending plus Shear).

Arrangements are being made for a commercial printing.

PROJECT NO:	SR-1269
PROJECT TITLE:	INTERNAL CORROSION AND CORROSION-CONTROL ALTERNATIVES
INVESTIGATOR:	Mr. C.R. Jordan
CONTRACTOR:	Newport News Shipbuilding and Drydock Company, Newport News, VA
ACTIVATION DATE:	January 14, 1980
CONTRACT FUNDING:	$50,850
SSC LONG-RANGE GOAL:	Materials Criteria
CONTRACT NUMBER:	DOT-CG-80-C-91291

OBJECTIVE

The objective of this project is to develop a method for making sensitivity studies of the relative life-cycle costs of corrosion control techniques--including combinations of increased scantlings, full or partial coatings, and anodes--to protect internal surfaces of ballast and cargo tanks in steel tankers as a means to rank corosion control systems.

RESULTS

The relative effectiveness of coatings, sacrificial anodes and full scantlings is evaluated for different tank conditions. It was found that it is not normally advantageous to reduce scantlings in fully protected cargo tanks and that a partially coated crude-oil tank will experience lower life-cycle costs than one fully coated. The final report, SSC-312, provides tanker owners and designers with a rationale for selecting an optimum corrosion-control system for a specific vessel by providing a better understanding of the factors which influence both tank corrosion and the cost of corrosion protection.

A method for life-cycle cost analysis for various tank conditions and the results of sensitivity studies on two representative ship designs are also included in the report.

PROJECT NO:	SR-1271
PROJECT TITLE:	PRESSURE DISTRIBUTION MODEL TESTS IN WAVES
INVESTIGATOR:	Prof. A.W. Troesch
CONTRACTOR:	Univ. of Michigan, Ann Arbor, MI
ACTIVATION DATE:	September 25, 1979
CONTRACT FUNDING:	$60,543
SSC LONG-RANGE GOAL:	Response Criteria
CONTRACT NUMBER:	DOT-CG-913367-A

OBJECTIVE

The objective of the project is to conduct model tests to measure hull surface pressures and compare them with calculated pressures.

RESULTS

Scale models of the SL-7 SEALAND McLEAN containership and the Great Lakes bulk carrier S.J. CORT were tested in head seas for a variety of speeds and wave lengths to measure pressures at various locations over the hull and to measure the separate components of pressure. Difraction pressures were also measured by restraining the model, and radiation pressures were measured by forcing the model to oscillate in heave and pitch. The results are presented in SSC-314.

The calculated pressures were not available for comparison.

PROJECT NO:	SR-1275
PROJECT TITLE:	FULL-SCALE PRESSURE DISTRIBUTION MEASUREMENTS OF M/V S.J. CORT
INVESTIGATOR:	Mr. A.L. Dinsenbacher
CONTRACTOR:	David Taylor Naval Ship Research and Development Center, Carderock, MD
ACTIVATION DATE:	December 19, 1978
CONTRACT FUNDING:	$76,700
SSC LONG-RANGE GOAL:	Response Criteria
CONTRACT NUMBER:	N6519779PO90714

OBJECTIVE

The objective of this project is to measure full-scale pressure distributions to validate pressure prediction analysis methods.

RESULTS

Full-scale pressure measurements from the M/V S J CORT have been completed. The maximum peak-to-peak pressure of 13.24 psi was measured 14 feet above the keel, between frames 9 and 10, in head seas while the ship was moving 14.7 miles per hour in 19 feet of draft. The pressure from the static head must be added to this value to obtain the total pressure.

Among the 119 data runs addressed, 13 were at a 45^{o} heading to the waves, 3 in beam seas, and 4 in following seas.

The American Bureau of Shipping is comparing their SHIPMOTION computer program results with selected runs, and will publish a separate report.

PROJECT NO:	SR-1279
PROJECT TITLE:	SL-7 PROGRAM SUMMARY, CONCLUSIONS AND RECOMMENDATIONS
INVESTIGATOR:	Mr. W.A. Wood
CONTRACTOR:	Giannotti and Associates, Inc., Annapolis, MD.
ACTIVATION DATE:	August 14, 1980
CONTRACT FUNDING:	$25,220
SSC LONG-RANGE GOAL:	Response Criteria
CONTRACT NUMBER:	DTCG-23-80-C-20025

OBJECTIVE

The objective of the study is to review and evaluate the plans, procedures, results and accomplishments of the SL-7 program.

RESULTS

A review and assessment of all SL-7 research programs has been completed. The SL-7 data represents one of the most extensive data bases obtained to date. It is recommended that maintenance of this data base by the SSC be continued and utilized as specific needs and applications arise, but it is not recommended that a detailed research plan for further use of the data be developed now.

The information has been valuable in validating the SCORES (hydrodynamic load and response prediction), DAISY (finite-element analysis), and the USCG time-domain (hydrodynamic load and response prediction for capsizing in following seas) computer programs. It has greatly increased the knowledge and understanding of the sea and the ships that sail on it.

PROJECT NO:	SR-1272
PROJECT TITLE:	COMPUTER-AIDED PROCEDURE FOR CALCULATING GROUNDED SHIP RESPONSES
INVESTIGATOR:	Unknown
CONTRACTOR:	Unknown
ACTIVATION DATE:	Unknown
CONTRACT FUNDING:	2000 Man-hours
SSC LONG-RANGE GOAL:	Advanced Concepts and Long-Range Planning
CONTRACT NUMBER:	Unknown

OBJECTIVE

The objective of this project is to design the logic for a computer program which will aid in the assessment of damage, stability and survivability of grounded tank ships, including LNG carriers.

STATUS

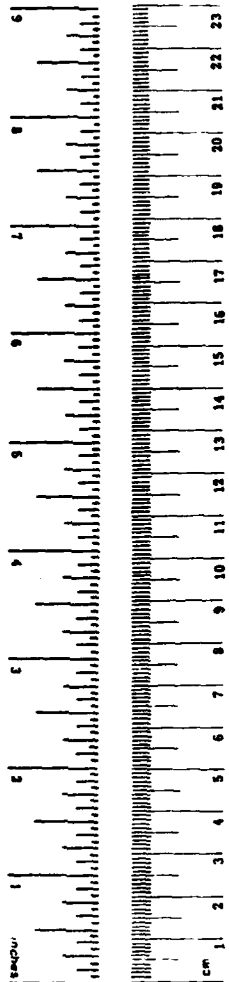
This project was never initiated. It has been set aside for SR-1294, "Calculation Aids for Predicting Grounded Ship Responses."

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

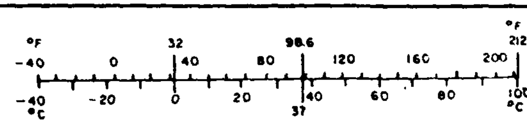
Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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16. Abstract

The Ship Research Committee (SRC) of the National Research Council provides technical services covering program recommendations, proposal evaluations, and project advice to the interagency Ship Structure Committee (SSC), composed of representatives from the U.S. Coast Guard, the Naval Sea Systems Command, the Military Sealift Command, the Maritime Administration, the American Bureau of Shipping, and the U.S. Geological Survey. This arrangement requires continuing interaction among the SRC, the SSC, the contracting agency, and the project investigators to assure an effective program to improve marine structures through an extension of knowledge of materials, fabrication methods, static and dynamic loading and response, and methods of analysis and design. This report contains the Ship Research Committee's recommended research program for five years, FY 1982-1986, with 13 specific prospectuses for FY 1983. Also included is a brief review of 21 active and 9 recently completed projects.

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THE NATIONAL ACADEMY OF SCIENCES is a private, honorary organization of more than 900 scientists and engineers elected on the basis of outstanding contributions to knowledge. Established by a Congressional Act of Incorporation signed by Abraham Lincoln on March 3, 1863, and supported by private and public funds, the Academy works to further science and its use for the general welfare by bringing together the most qualified individuals to deal with scientific and technological problems of broad significance.

Under the terms of its Congressional charter, the Academy is also called upon to act as an official - yet independent - advisor to the Federal Government in any matter of science and technology. This provision accounts for the close ties that have always existed between the Academy and the Government, although the Academy is not a governmental agency and its activities are not limited to those on behalf of the Government.

THE NATIONAL ACADEMY OF ENGINEERING was established on December 5, 1964. On that date, the Council of the National Academy of Sciences, under the Authority of its Act of Incorporation, adopted Articles of Organization bringing the National Academy of Engineering into being, independent and autonomous in its organization and the election of its members, and closely coordinated with the National Academy of Sciences in its advisory activities. The two Academies join in the furtherance of science and engineering and share the responsibility of advising the Federal Government, upon request, on any subject of science or technology.

THE NATIONAL RESEARCH COUNCIL was established in 1916, at the request of President Woodrow Wilson, by the National Academy of Sciences to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and of advising the federal government. The Council operates in accordance with general policies determined by the Academy by authority of its Congressional charter of 1863, which establishes the Academy as a private, non-profit, self-governing membership corporation. Administered jointly by the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine (all three of which operate under the charter of the National Academy of Sciences), the Council is their principal agency for the conduct of their services to the government, the public, and the scientific and engineering communities.

Supported by private and public contributions, grants, and contracts, and voluntary contributions of time and effort by several thousand of the nation's leading scientists and engineers, the Academies and their Research Council thus work to serve the national interest, to foster the sound development of science and engineering, and to promote their effective application for the benefit of society.

THE COMMISSION ON SOCIOTECHNICAL SYSTEMS is one of the major components of the National Research Council and has general responsibility for and cognizance over those program areas concerned with physical, technological, and industrial systems that are or may be deployed in the public or private sector to serve societal needs.

THE MARITIME TRANSPORTATION RESEARCH BOARD is an operating unit of the Commission on Sociotechnical Systems of the National Research Council. The role of MTRB is to stimulate research, and advise on applications, in the broad field of maritime transportation. The Board provides guidance within the NRC for maritime transportation and marine transportation systems, including impact of such systems on the economy and society; improvement of ships, cargo handling, ports and marine facilities; education, training and working conditions of marine personnel; and relationship of elements of the marine transportation system to other transportation, economic, and social systems. The role of the merchant marine in national defense is a vital part of the Board's program.